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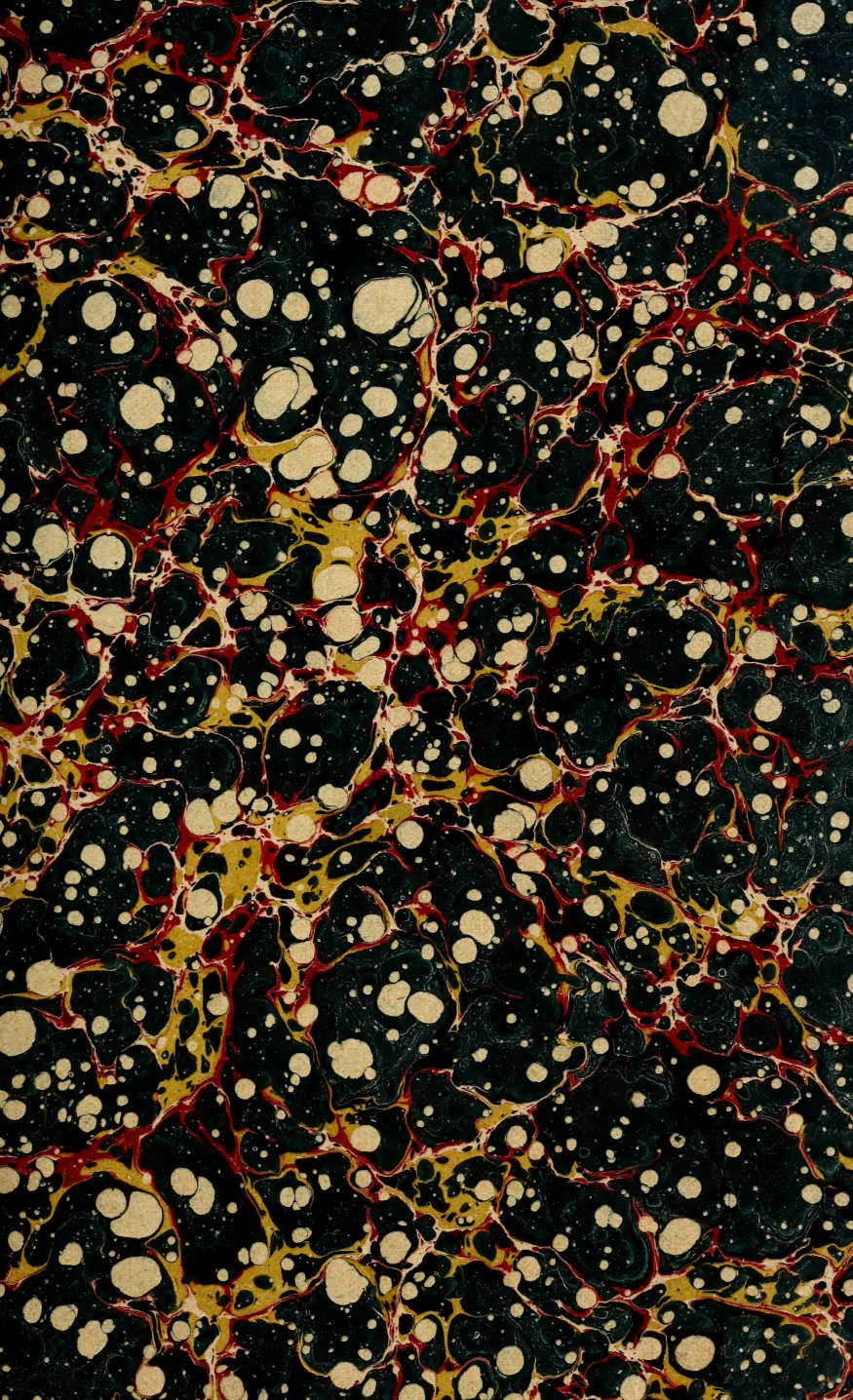


THE

CANADIAN NATURALIST

AND

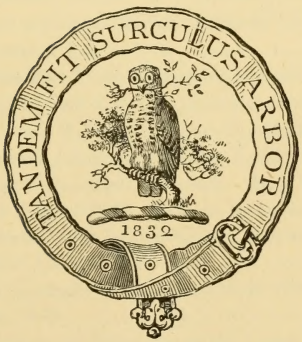
Quarterly Journal of Science.

WITH THE

PROCEEDINGS OF THE NATURAL HISTORY SOCIETY OF MONTREAL:

B. J. HARRINGTON, B. A., PH. D.
EDITOR.

NEW SERIES,—Vol. 8.



MONTREAL:
DAWSON BROTHERS, ST. JAMES STREET.
1878.

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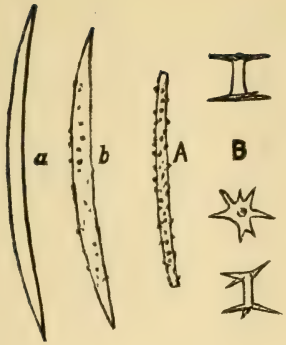

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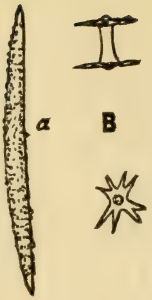

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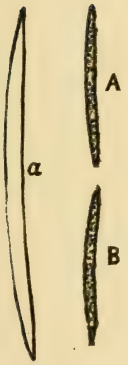

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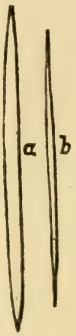

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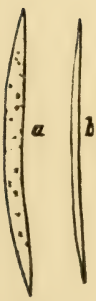

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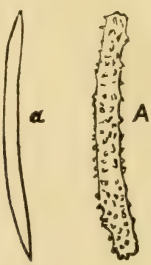

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Figs. 1 & 5. *Spongilla stagnalis.*
" 2. " *asperrima.*
" 3. " *Dawsoni.*

Fig. 4. *Spongilla flexispina.*
" 5. " *Ottawaensis.*

THE

CANADIAN NATURALIST

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Quarterly Journal of Science.

ON SOME CANADIAN SPECIES OF SPONGILLÆ.

By George M. Dawson.

The *Spongillidæ* or fresh-water representatives of the marine sponges, though very widely distributed, are not yet known to be represented by a great number of species. It is probable that a systematic exploration of the great North American systems of lakes and rivers might bring many new forms to light. With the exception of *S. Lordii*, Bowerbank, from the sources of the Columbia River, the only Canadian spongilla which appears to have been described, is *S. Dawsoni*, of the same author, a form inhabiting the St. Lawrence River near Montreal, and other neighbouring waters.

Having become interested in the examination of a fine species from the Lake of the Woods, obtained in connection with the work of the British North American Boundary Commission, I have been induced, at the same time, to examine a number of other specimens in the collection of Principal Dawson. Among these, and including the Lake of the Woods form, I find four species which I believe to be undescribed. These are here defined, and though I have not the whole of the literature of the subject at hand, provisionally named.

The descriptions, from the poor state of some of the specimens, are necessarily not in all cases complete; but will, I believe, at least serve for the recognition of the species, with the aid of the figures.

The first spongillas studied—*S. fluviatilis* and *S. lacustris*—belong to two distinct types; and it has been found, on extend-

ing the knowledge of the genus, that all new forms fall naturally into one or other of these. To this rule the forms now under consideration offer no exception, though representing both groups; *S. stagnalis* and *S. asperrima*, belonging to the fluviatilis type, *S. flexispina* and *S. Ottawaensis*, to that of lacustris.

In the first series, are included those spongillas in which the gemmule, or reproductive capsule, is built up of birotulate spicula, placed side by side, and arranged with their axes radially. In the second, the capsules are more leathery, but covered, when mature, with straight or curved spicula, arranged at right angles to the radial lines.

For details concerning the classification and morphology of the *Spongillidæ*, reference should be made to Dr. Bowerbank's and Mr. Carter's Memoirs.

I append first Dr. Bowerbank's description of *S. Dawsoni*, as given in his monograph on the *Spongillidæ*.*

Spongilla Dawsoni, Bowerbank. "Sponge sessile?, branching; surface smooth, oscula and pores inconspicuous. Dermal and interstitial membranes abundantly spiculous; spicula fusiformi-acerate, entirely spined; spines numerous, short, and conical. Skeleton-spicula acerate or subfusiformi-acerate. Ovaria spherical: dermal spicula numerous, disposed in flat fasciculi, or groups of spicula parallel to each other; groups irregularly dispersed; spicula acerate or subcylindrical, entirely spined; spines numerous, obtuse, and ill-defined. Sarcode aspiculous. Colour, in the dried state, emerald-green."

Hab., River St. Lawrence, Montreal; a lake near Brockville.

Dr. Bowerbank further adds, with reference ro this species:

"The dermal and interstitial membranes abound with tension-spicula, and especially the dermal one, in which they seem to attain their fullest degree of development. Their normal form is fusiformi-acerate; but, from the abundant production of the spines at their terminations, they frequently appear to be cylindrical rather than acerate. They are disposed on these tissues rather unevenly, abounding in some spots, while they are comparatively scarce in others."

"The spicula of the skeleton are of about the same proportions as those of the European species. They are usually of the regular acerate form, but occasionally become subfusiform."

---

* Proc. Zool. Soc. London, Nov. 1863, and *Canadian Naturalist*, 1864.

The spongilla is sessile, and branches much, well-grown specimens much resembling fully developed examples of *S. lacustris*.

Length of skeleton-spicula 0.013. Dermal and interstitial spicula, 0.0015 to 0.0017 inch.

Fig. 3.—*a*, ordinary skeleton-spiculum. A. and B., ordinary capsular and dermal spicula.

Spongilla stagnalis, sp. nov. Sponge encrusting, forming patches several inches in diameter, and from half an inch to an inch thick; greenish; lobular, somewhat hispid. Oscula simple, key-hole shaped, or double; large, 0.25 to 0.50 in. Scattered, sub-crateriform. Skeleton-spicula acerate and fusiformi-acerate, slightly arcuate, 0.011 to 0.013 in. long. Most of the stouter spicula medially spined, the apices always naked; spines small, sparsely distributed. Ovaria, sub-globose, diameter, 0.025 in. Rotulæ, about equal in size, flat, very deeply and irregularly dentate, diameter about equal to length of shaft of spiculum, or 0.0005 in.; the rays not acute. Shaft, thick, cylindrical, generally with a boss at each end.

Hab. North-west Angle Inlet, Lake of the Woods; River St. Lawrence near Montreal.

The two forms of skeleton spicula seem to pass into each other, and in specimens from both localities, are very irregular in size. The birotulate spicula—especially in the Lake of the Woods specimens—are very apt to be deformed. A number of small, entirely spined, straight, obtuse spicula, about one-third the length of the skeleton-spicula, were found with the others, after treatment with acid. They were searched for in all parts of the sponge, but finally found enclosed in some of the gemmules, and apparently in connection with the young sponge.

This species, which is nearest the European type *S. fluviatilis*, of Johnston, was found in great abundance at the first mentioned locality, in July, 1873. It was growing on floating logs and branches, and many specimens were filled with large gemmules. It is probably the species the existence of which was suspected by Dr. Bowerbank, who says, in the conclusion of his notice of *S. Dawsoni*:—"In the preparation of these spicula for examination, I found a few birotulate ones, having the rotulæ very deeply divided. These spicula were no part of the sponge in course of description, but were undoubtedly from the gemmules of another species inhabiting the St. Lawrence."

Fig. 1.—*a.* and *b.*, ordinary skeleton-spicula. B., birotulate spicula. The middle figure shows one end of a spiculum, of about the ordinary form; the lower figure, a type of deformed spiculum which is common. All the above drawn from Lake of the Woods specimens. Fig. 5. represents skeleton-spicula of a specimen from the St. Lawrence.

Spongilla Baileyi, Bowerbank. This species appears to be indicated by a single birotulate spiculum, in the Lake of the Woods collection. It was originally described by Dr. Bowerbank, from specimens obtained at West Point, N. Y.

Spongilla asperrima, sp. nov. Sponge sessile, encrusting, thin; surface slightly undulated; oscula rather large, scattered; skeleton-spicula, fusiformi-acerate, slightly arcuate, stout, densely spined, with the exception of the extreme apices; length, 0.01 to 0.009 in. These mixed with a few smooth and more slender. Spines minute, acute. Ovaria sub-globose, diameter nearly 0.02; spicula birotulate, short; rotulæ equal in size, flat, very deeply divided, about 0.0005 in., equal to, or greater than, the length of the shaft; radii not acute; shaft with a distinct boss at each end.

Hab., River St. Lawrence, near Montreal.

This species much resembles that from the Lake of the Woods, of which, it is possible, it may turn out to be a variety. It differs chiefly in its thicker, coarser and much more densely spinous skeleton-spicula, and in the external form of the sponge. Not possessing any intermediate forms, I have referred them, for the present at least, to different species. The spicula are not unlike *S. Parfitii*, as figured by Bowerbank,* but differ from them about as much as from those of the Lake of the Woods. Many of the skeleton-spicula are deformed, having crutch-like or bent ends.

Fig. 2., *a.*, ordinary skeleton-spiculum. B., one of the ordinary birotulate spicula.

Spongilla flexispina, sp. nov. Specimens not large enough to show the general form, or appearance of the surface. Skeleton-spicula acerate to subfusiformi-acerate, very slightly arcuate to nearly straight, smooth, not very acute, length about 0.0115 in. Dermal and interstitial spicula subcylindrical, irregularly and

* Brit. Spongiadæ, Vol. III., Plate LXXXVI.

often abruptly bent, entirely spined, length nearly 0.003 in.; spines scattered, rather large, conical, acute, generally retrorse near the ends of the spicula. Ovarian spicula scarcely distinguishable from the interstitial and dermal.

Hab., River St. Lawrence, near Montreal.

This species is of the type of the European *S. lacustris*, but differs sufficiently from that species. It also differs markedly from *S. Dawsoni* and *S. Ottawaensis*. Its ovarian and dermal spicula are intermediate in size between those of the last named species.

Fig. 4.—*a.*, ordinary skeleton-spiculum. *b.*, a second form of skeleton-spiculum, smaller and perhaps not fully developed. B., C., ovarian and dermal spicula.

Spongilla Ottawaensis, sp. nov. Specimens do not show the external form. Colour in the dried state, green. Skeleton-spicula acerate, slightly arcuate, often rather abruptly and bluntly pointed, smooth, length, 0.011 to 0.008 in. Ovaria sub-globose, rather irregular, large, diameter 0.04 in.; spicula cylindrical, stout, slightly and regularly arcuate, entirely and rather densely spined, length 0.0034; spines rather prominent, somewhat obtuse. Dermal and interstitial spicula like the ovarian, but slightly more delicate.

Hab., L'Orignal, on the Ottawa River.

The skeleton-spicula are shorter than those of *S. Dawsoni*; the ovarian etc. spicula much larger than those of that species, and larger also than those of *S. flexispina*. They somewhat resemble those of *S. lacustris*, but are distinctly truncate at the extremities. The specimens are small, but densely filled with large ovaria.

Fig. 6.—*a.*, ordinary skeleton-spicula. A., ovarian spicula.

NATURAL HISTORY SOCIETY.

PROCEEDINGS FOR THE SESSION 1874–75.

FIELD DAY.

A Field Day to Belœil Mountain was held on the 24th of May, which was very numerously attended. The spring being unusually late, the collections of plants, &c., were not so large as they otherwise might have been. From the summit of the mountain, addresses relating to the geology and history of the surrounding district were delivered by the President, A. R. C. Selwyn, F. R. S., by Principal Dawson and Rev. Dr. De Sola.

The following prizes were awarded during the afternoon:

1. For the best named collection in any department of Natural History.—Captain F. S. Barnjum.

2. For the largest number of species of Flowering Plants, unnamed.—Mr. Rankine Dawson.

3. For the second best ditto.—Miss Grace Lyman.

MONTHLY MEETINGS.

1st Monthly Meeting, held October 26th, 1874.

The Hon. Donald Smith, M. P., was elected a member of the Society.

Dr. J. Baker Edwards exhibited a sample box of materials for chemical experiments, prepared by Dr. May, of Toronto, for the use of schools, and commented on the cheapness of these portable cabinets, and their use to young students.

Mr. Whiteaves then read a paper on the Marine Fisheries and Oyster Beds of the Gulf of St. Lawrence. This will be found (condensed) on pages 336–349 of the last volume of this journal.

2d Monthly Meeting, held Dec. 7th, 1874.

Postponed from Nov. 30th, 1874, that being St. Andrews's Day.

Dr. W. Osler and Messrs. James Fletcher, Arthur Webster, W. Campbell and Thomas W. Evans were elected members of the Society.

Principal Dawson then read a communication on Indian Remains from Lake St. Francis and elsewhere.

A discussion ensued, in which the President, Mr. Leslie, Mr. Marler and Mr. E. E. Shelton took part.

3rd Monthly Meeting, held Feb. 1st, 1875. (This meeting was also adjourned from Jan. 25th, 1875.)

Mr. James Esplin was elected a member of the Society.

Mr. G. M. Dawson read a paper entitled: "On the Superficial Features and Geology of the Plains, from the Lake of the Woods to the Rocky Mountains."

Supplementary remarks on this topic were then made by Mr. Selwyn, Prof. Bell and Principal Dawson.

4th Monthly Meeting, held Feb. 22nd, 1875.

Dr. G. A. Baynes and Messrs G. W. Reed, J. G. Bowles and W. Cowie were elected resident members.

Principal Dawson made a communication on two Indian Skulls recently obtained by Mr. Richardson from the vicinity of Victoria, Vancouver Island.

At the request of the President, the Rev. J. B. Good, of British Columbia, made some remarks on this subject and on the distribution of the Indian Tribes on the N. W. Coast.

Dr. P. P. Carpenter gave an account of a collection of Sea Shells made by Mr. Richardson in the Gulf of Georgia.

Mr. Whiteaves also commented on other marines invertebrates from that region, which were exhibited at the meeting.

Remarks on Mr. Richardson's collection were also made by the President, by Principal Dawson and Mr. G. M. Dawson.

5th Monthly Meeting, held March 29th, 1875.

Dr. G. B. Shaw was elected a resident member.

Mr. Whiteaves read a paper on some Algæ, Marine Invertebrates and Cretaceous Fossils from British Columbia.

6th Monthly Meeting, held April 26th, 1875.

Messrs. R. Stanley Clark Bagg; David Aikman, J. Hedley, H. McLaren and G. Sumner were elected members.

Mr. E. B. Caulfield read a paper on Insect Life in the vicinity of Montreal.

Remarks on this topic were made by Messrs. Marler, Whiteaves and other members.

Mr. R. W. McLachlan also read a paper on Indian Stone Pipes.

Some discussion ensued, and the proceedings terminated by the passing of a vote of thanks to the lecturers.

SOMMERVILLE LECTURES.

The above course of free scientific lectures was duly delivered as follows :

1. March 4th, 1875. On Electricity, with experiments, by Dr. G. B. Shaw.
2. March 11th, " On the Adulteration of Food, by J. Baker Edwards, Ph. D., D.C.L., F.C.S.
3. March 25th, " The Grasshopper Plague of the North-West, by Prof. R. Bell, F.G.S., F.C.S.
4. April 1st, " The Transit of Venus, by Richard Johnson, M. A., F. R. A. S., Chief Astronomer at Kauai, Sandwich Islands, British Transit Expedition.
5. April 8th, " Matter out of place, by Dr. G. P. Girdwood.
6. April 15th, " The Nose, its Uses and Duties, by Dr. P. P. Carpenter.

ANNUAL MEETING.

The Annual Meeting was held on the 18th of May, 1875, Rev. Dr. De Sola in the Chair.

The minutes of the last Annual Meeting having been read by the Recording Secretary, Principal Dawson delivered the following address, the President being absent in British Columbia.

ANNUAL ADDRESS.

I propose to devote the greater part of this address to memories of a man whose death may almost be said to close an era in the history of geological progress, as the publication of his greatest work, the Principles of Geology, may be held to have begun an era in the study of that science, whose goal of to-day will ever be its starting point for to-morrow. Sir Charles Lyell, the greatest geological thinker of our time and nation, died on the 22nd of February, in his seventy-eighth year. He was born at Kinnordy in Forfarshire, on the 14th of November, 1797, and graduated at Oxford, in 1819. He studied for the Bar, and began the practice of his profession ; but his mind was already occupied with inquiries as to the structure of the earth, stimulated apparently by Buckland's lectures, to which he had listened at Oxford. In 1824, he became an honorary secretary of the Geological Society of London, and for a time he was Professor of Geology in King's College, London. He was elected,

for the first time, President of the Geological Society in 1836.

Sir Charles received the honor of knighthood in 1848, and was raised to a baronetcy in 1864. He had the degree of D.C.L. from Oxford and that of LL.D. from Cambridge. He was thrice president of the Geological Society, and once of the British Association.

He married in 1832 the eldest daughter of Leonard Horner, himself a good geologist, and a friend and helper of Lyell in his earlier work; and his wife not only graced his home and sedulously attended to all the wants and interests of a man too devoted to his specialties to give much attention to the ordinary affairs of life, but shared the fatigues of his journeys, and gave no small help in many of his works, being herself well acquainted with natural history and an accomplished linguist. Her death, less than two years ago, deprived his old age of its chief earthly stay.

In January, 1830, the first volume of his Principles of Geology appeared, and was followed by the second in January, 1832, and by the third in the following year. This work has reached its eleventh edition; and with the Elements or Manual of Geology, which followed, it may be said to have done more than any other book to shape the geological science of the time. More especially the doctrine of reference to existing causes for the explanation of all geological phenomena, at once removed theoretical geology from a speculative to an inductive basis, and laid a stable foundation for a history of the earth. Though Lyell published many detached geological memoirs, and also gave to the world very instructive and interesting narratives of his travels in America, and latterly summed up the facts and conclusions at present reached with reference to the latest geological period, in his "Antiquity of Man," his great fame must rest on his Principles of Geology, and on the effect of this work in giving form to geological science.

While the name and fame of Lyell belong to the world, we in British America and our brother geologists of the United States have some special cause to revere his memory, because of his world-wide grasp of the subjects he studied, and because of his eminent services to our own local geology and geologists; and, as examples of these, I shall take the liberty of referring to some of them which came under my own personal observation.

The visits of Sir Charles Lyell to America were three in

number, though detailed narratives of two only were published. The first, in 1841, was made in pursuance of his determination to verify for himself, as far as possible, all geological facts to which he had occasion to refer—a determination justified not only by the love of truth, but by his own great powers of appreciating the nature and relations of phenomena, and of presenting them to the minds of others. He had, on this occasion, an invitation to lecture for the Lowell Institute of Boston, which kept him some time in that city; but he took time to travel very extensively both in Canada and the United States.

His second visit to America was made in 1845, and on this occasion, he merely called at Halifax, and did not travel in British North America. He devoted his whole time to the United States, and more especially to the South. In 1853, he was named one of the Commissioners to the Great Exhibition in New York, and on this third visit he landed in Halifax and spent some time in Nova Scotia and New Brunswick.

I had the pleasure of first meeting Sir Charles in 1841, when he spent a few weeks in the Maritime Provinces of British America. I had just returned from the University of Edinburgh and from the somewhat careful training in mineralogy and lithology of the veteran Jameson, and had already given some time and study to the Carboniferous rocks of my native province. In these circumstances, the visit of Lyell was most opportune for me; and from my local knowledge, I was able to give him some aid in unravelling those complexities of the Carboniferous beds, to which at the time his attention was earnestly directed. I accordingly accompanied him in the remainder of his tour in Nova Scotia, and after his departure, followed up his work in districts which he had been unable to reach. We have met many times since, both in England and in this country, and have regularly corresponded down to within a very short time of his death; and I have ever found him a warm friend, and intensely interested in all that concerned the growth of natural science in this country.

The benefits rendered by Sir Charles to American Geology in his several visits to this continent, it would not be easy to overestimate. At the time of his first visit, few English geologists had seen those great breadths of the older and of the more recent formations by which this continent is distinguished, or had the means of realizing for themselves the resemblances and

differences of the formations on the opposite sides of the Atlantic; and American and British workers in these subjects were little known to each other. The visits of Sir Charles did much to remedy all this. His own mind was filled with those grander aspects of geological phenomena which appear in America. He brought into correspondence with each other those workers in science, whom his intuitive tact perceived to be suited to give mutual aid. In British America, in particular, his agency in this way was very valuable in bringing together the widely-separated cultivators of science, and in linking them with the scientific movement of the mother country.

Nor were his visits barren of purely scientific results. He may have made few discoveries of new facts,—and he had not time to enter into detailed stratigraphical studies;—but in a thousand instances he cast new light on obscure facts, and gathered into a harmonious union detached fragments of evidence, and suggested new conclusions and interpretations. Of this character were his re-arrangement of the Carboniferous rocks of Nova Scotia and New Brunswick; and the clear conceptions which he formed of the nature and origin of our Post-pliocene formations, and which are still, I think, in advance of those currently taught on this side of the Atlantic.

Limited though his time for observation was, he always seized the salient and important points of any formation or locality; and I have often been struck with the truthfulness and completeness of the sketches which he gave of phenomena with reference to which his opportunities of collecting information were very imperfect.

In these American researches, the great gifts of the man were brought out in a light somewhat different from that in which they appear in his general works. The main distinction between Sir Charles and most of his contemporaries, was his eminence as a thinker, whether in inductive or deductive reasoning. Like most of the English geologists of his time, he had received less training in the characters of minerals and rocks than that which the more severe schools of science exacted, and his imperfect vision was a great hindrance in field work, and sometimes even a source of personal danger; but when facts, however complex, were once obtained, they grouped themselves in his mind in their natural relations, with an unfailing certainty, while their connections with all the other parts of his vast stores of know-

ledge and the general conclusions deducible from them, came out with a degree of clearness always beautiful, and often even startling.

Another quality of his mind was the fresh and vivid interest, almost childlike, which every new truth awakened in him. This feeling is more or less that of every true naturalist. It depends on the clear perception of what is presented to us, and on the keen realization of its relations to things previously known, and perhaps still more on the sudden breaking of those new relations upon the mind as if with a flash of divine light. I well remember how, after we had disinterred the bones of Dendrerpeton from the interior of a large fossil tree on the Joggins shore, his thoughts ran rapidly over all the strange circumstances of the burial of the animal, its geological age, and its possible relations to reptiles and other animals, and he enlarged enthusiastically on these points, till suddenly observing the astonishment of a man who accompanied us, he abruptly turned to me and whispered: "The man will think us mad if I run on in this way."

An allied feature of his mental character was the readiness with which he accepted new conclusions and relinquished without regret views which he might have long held, when he perceived them to be shaken or untenable. He seemed wholly free from that common failing of men of science which causes them to cling with such tenacity to opinions once formed, even in the face of the strongest evidence. This quality eminently fitted him to be the exposi'or of a rapidly advancing science, and also to be the patron and helper of younger and less eminent men, and was connected with that warm and earnest interest which he ever felt in the progress of knowledge, and with the deference with which he received new facts and suggestions from any quarter.

These qualities, apparent in his connections with American Geology, were equally valuable in his relations to science in its general aspect. A man so gifted, fortunate in his genius, his education, his outward circumstances, and in his appearance on the stage at a time when Geology had gathered in some of its greatest harvests of facts, and was waiting for a master mind to arrange them, had a great opportunity, which Lyell had the energy and ability to seize. He was thus able to become the guiding mind among his contemporaries in geological theory, and to

hold his pre-eminence down to the end of his life, and through all the great changes which occurred in the rapid development of the science. For nearly 45 years, his works have been the text-books of geologists, and though the great impetus which they primarily gave has thrown the study of the earth forward into an entirely new position:—the last editions of the Elements and Principles are still in the van of the science.

The position which he thus occupied is one to which he was in every way justly entitled. His large and judicial mind had always a clear perception of the true method of natural history. He saw that the foundations of our knowledge of geology were to be laid in extensive and accurate collections of facts, and in reasoning on these by severely inductive methods. This idea he carried out in his Elements of Geology. But in his Principles he opened up a new field, not as has been crudely conceived by some commentators on his work, one of the nature of deduction as distinguished from induction, but rather another inductive investigation, leading to general conclusions as to the changes now in progress, in order that by a fair use of analogy a key might be found to the interpretation of the facts and conclusions obtained by the study of the geological monuments of past ages. He has himself well stated this view of the case in the preface to the tenth edition of the Principles.

Viewed in this way, the Lyellian Geology rests on two inductive bases—the first relating to the facts discoverable in the earth's crust, and the second to the changes now in progress under our observation—and the connection of these by an analogy founded on identity of causes or conditions and identity of effects. This mode of treating the history of the earth was especially that of Lyell, and it was this that constituted his greatest contribution to the growth of modern geology.

Injustice has been done to the Lyellean method by two misconceptions, propagated perhaps by injudicious friends rather than by opponents, and which have arisen from a failure to enter into the grand comprehensive views of this great reasoner.

One of these is the representation that Lyell was thoroughly uniformitarian, in the sense of maintaining that similar changes had been taking place throughout all geological time. It is true that he objected to any explanation of geological changes by imaginary cataclysms not warranted by observation of similar facts; but no one was more ready than he to receive any

evidence of change, or physical or organic action, whether sudden or gradual, as a geological course, provided it could be shown to be or to have been a natural fact. Farther, no one was more fully impressed with the continual change and progress in nature, and with the necessity of taking into account the different conditions of different geological times, in applying any modern cause to account for ancient phenomena.

A second and still more mischievous misapprehension is that of regarding his method as similar to that style of analogical reasoning which Spencer and Darwin have made so current in our time. When Lyell strove to illustrate the conditions of the Coal period by those of the great Dismal Swamp, for example, his argument was one of analogy, but an analogy in which the main conditions could be proved to be identical. In both cases they were swamp conditions, though separated by a great lapse of time. He never would have reasoned, like Spencer, that the evolution of an egg explains the evolution of animals in geological time; because in this case the similarity of conditions which can alone give value to a natural analogy is wholly absent. Nor does the Lyellian philosophy properly admit the assumption, as a *vera causa* of past geological change, of processes supposed to be going on, but so slowly that human experience fails to obtain any measure of them, or even any certainty as to their reality. It is true that, in the later editions of the Principles, Sir Charles admits the force of Darwin's arguments for the transmutation of species, and devotes large space to their exposition; and he states, as his general conclusion, that Darwin, "without absolutely proving this, has made it appear in the highest degree probable;" but I do not find that he ever regarded these brilliant speculations as occupying the same stable ground with his own grand general conclusions as to the persistency of existing causes in geological time. Lyell, in short, while a uniformitarian rather than a cataclysmist, held to uniformity not of effects, but of the general laws of causation; and the analogies by which he sought to connect modern changes with those which had left their monuments on the earth's crust, had nothing in common with those on which theories of transmutation of species have been based.

It is always an interesting inquiry in the case of a great student of nature, to ask what position he took in regard to those higher problems which directly affect man in his mental, mora

and spiritual nature. There is nothing in the study of nature to withdraw a man from sympathy with his fellows; and men of science who have so shut themselves up in their specialties as to take no interest in the general welfare and progress of society, have necessarily failed to secure for themselves and their subjects the hearty interest of mankind. In these respects, Lyell was characterized by the same breadth which appears in his scientific investigations and reasonings. He was a warm personal friend, and full of sincere sympathy with all that concerned those he loved. He was active and earnest in promoting education and the diffusion of knowledge, and he took a lively interest in all movements for improving the social and political condition of mankind. He was quite free from that tendency to attack or sneer at everything that other men hold sacred, which characterizes some of the advanced writers of the day. He neither tormented himself with the gloomy idea that men looked askance upon him and desired to persecute him, nor did he desire to make any other man a martyr to his faith. In the earlier editions of the Principles, he closed the work with a few paragraphs of "Concluding Remarks," in which he repelled the imputation that his doctrine of modern causes was equivalent to the assumption that "there never was a beginning of the present order of things;" and he takes occasion to state his doctrine of the relation of natural science to religion in the following words, which, I find, remain unchanged in the last edition :—

"We aspire in vain to assign limits to the works of creation in space, whether we examine the starry heavens or that world of minute animalcules which is revealed to us by the microscope, we are prepared therefore to find that in time also the confines of the universe lie beyond the reach of mortal man. But in whatever direction we pursue our researches, whether in time or space, we discover everywhere the clear proofs of a Creative Intelligence, and of his foresight, wisdom and power. As geologists, we learn that it is not merely the present condition of the globe which is suited to the accommodation of myriads of living creatures, but that many former states also were adapted to the organization and habits of prior races of being. The disposition of the seas, continents and islands, and the climates have varied; the species likewise have been changed, and yet they have all been so modelled on types analogous to those of

existing plants and animals, as to indicate throughout a perfect harmony of design and unity of purpose. To assume that the evidence of the beginning and end of so vast a scheme lies within the reach of our speculations, appears to be inconsistent with a just estimate of the relations which subsist between the finite powers of man and the attributes of an Infinite and Eternal Being."

I have left but a little time to speak of the work of our own society in the past year. Six meetings for the reading of papers have been held during the winter. The subjects discussed at these might well afford some material for interesting remark; but, as the substance of them has been or will be published, this is scarcely necessary. In geology, our papers have related chiefly to the west. Mr. Whiteaves has described to us some of the Cretaceous marine fossils from British Columbia, which are found there associated with and underlying the remarkable coal fields of Cretaceous age containing remains of so many dicotyledonous trees. Mr. G. M. Dawson has given us some interesting expositions of the geographical features and superficial deposits of the little-known region along the 49th parallel, between the Red River and the Rocky Mountains, which are to be illustrated in his forthcoming Report on that region. In ethnology, we have had papers on Indian Remains from Lake St. Francis, and Mr. Richardson's Collections in British Columbia; and Mr. McLachlan has described some curious Indian Pipes. Dr. Carpenter, Mr. Whiteaves, Mr. Caulfield and others have directed our attention to a variety of zoological subjects connected with the natural history of the Dominion; and the economic aspects of natural history were well presented to us by the former gentleman in his memoir on our marine fisheries and oyster beds. It is to be regretted that our dredging operations could not be continued last summer; but it is to be hoped that something may be done this year, if not by government aid, at least by private enterprise. Should the arrangements to be referred to in the Report of the Council for the association of the Society with the Fraser Institute be carried into effect, it is to be hoped that they may give a new stimulus to our work; and may relieve the Society from much of the difficulty hitherto experienced in sustaining its library and museum, leaving it more free to pursue its work of scientific research and publication, and of popular education in science.

The report of the Chairman of Council was next read by Mr. G. L. Marler, as follows:

REPORT OF THE CHAIRMAN OF COUNCIL.

Your Council, at the end of their year of office, respectfully report as follows:

That the regular Monthly Meetings have been held, to the number of six, at which nine papers have been read. A list of these will be found in the Proceedings of the Society for the year just closed.

Your Council have also to report that negociations have been entered into between the "Fraser Institute," the "Royal Institution for the promotion of Learning," and this Society, with a view to the union of the latter with the Fraser Institute, in order to establish a Free Museum of Natural History and Archæology.

The President and Principal Dawson were appointed a Committee to confer with the Governors of the Fraser Institute, and a preliminary memorandum of the conditions of union has been prepared. Some progress in the matter has been made, the proposition for the said union being favorably entertained by the Governors of the Fraser Institute. Special application was also made by this Society to the Royal Institution for the advancement of Learning to obtain its consent to such amalgamation, subject to the same rights in the new museum as its professors and students now possess. Further action in the matter has been delayed, in consequence of the absence of the Honorable Mr. Abbott, one of the Trustees of the Fraser Institute, in England. On his return, these negociations will be resumed.

A Field Day was held on the 24th of May, 1874, at Belœil Mountain, and nothwithstanding the unfavourable state of the weather the excursion was a decided success. A large number of people took part in it, a very pleasant day was spent, and prizes were awarded for the best collections made. Your council would suggest to the incoming officers that these Field Days should be continued.

Your Council would further report that the operations of its Scientific Curator in Dredging in the Gulf of the St. Lawrence were discontinued this year, through the inability of the Minister of Marine and Fisheries to place one of the Government vessels at his disposal, as on former occasions.

The Lecture-Room was rented, during the winter, to the Montreal Branch of the Entomological Society of Ontario, also to Mr. W. Muir, and the proceeds of such rental—amounting to $202—will be found credited by the Treasurer in his accounts to be submitted this evening.

Your Council have also to report an addition of seventeen ordinary members, as having been elected during the past year.

The number of visitors to the Museum has increased somewhat there having been about 1200 in the session which closes this evening.

The Sommerville Course of Free Lectures has been duly delivered, a list of which, with the Lecturers' names, will be found in the Society's Proceedings.

The annual grant of $750 from the Legislature of the Province of Quebec has also been duly received.

Your Council recommend that application be again made to the Local Government for an increase of this grant to $1000.

Finally, your Council would again urge on the incoming Officers the desirability of trying to make the Library, which is now incomplete, more useful to its members, and to the students of Natural History generally.

The subjoined report of the Scientific Curator and Rec. Secretary was then read by Mr. Whiteaves:

REPORT OF THE SCIENTIFIC CURATOR.

Since the last annual meeting, considerable time has been devoted to the study of some of the most difficult marine animals obtained in four late dredging expeditions to the Gulf of St. Lawrence. So many specimens were collected on these occasions, that it will be probably some years before the whole of them are correctly determined.

The Foraminifera have been exhaustively examined, and some of the more critical forms have been sent to Dr. Parker. With the exception of a solitary species, the entire series has been now identified. The microscopic crustacea, such as the entomostraca and copepods, have been forwarded to Messrs. Robertson and Brady, who have kindly named all but a few still doubtful forms, which are believed to be new to science.

All the amphipods of the Gulf have been submitted to Prof. S. J. Smith, of Yale College, New Haven, the only authority on this subject in the United States, who has just communicated to me the results of his latest studies on these difficult crustacea.

Many of the polyzoa have also been examined microscopically, and some of the most doubtful species have been sent to the Rev. A. M Norman, who is one of the best European authorities on this group. About twenty of these molluscoids, whose specific relations were doubtful, have been now determined satisfactorily. Some of the St. Lawrence polyzoa have also been sent, by request, to Prof. A. E. Verrill, who is engaged on a new work on the invertebrata of Northern New England.

The Dominion Government has decided, for the present, to discontinue the dredging explorations, a determination which, it is hoped, will soon be reconsidered.

Through the zeal of Mr. Richardson and the liberality of the Director of the Geological Survey, the Society has recently received a valuable collection of natural history specimens and ethnological objects, from various parts of British Columbia. Among these are a collection of flowering plants of great interest, a large series of marine animals, some Indian skulls and other miscellaneous objects. The plants have been carefully determined by Mr. Barnston, end the marine shells by Dr. P. P. Carpenter. The land and fresh-water shells and the crustacea have also been examined and named, and the alcyonaria, echinodermata, polyzoa and cephalopoda have also been partially studied. As soon as the specific relations of these and the hydroids have been properly ascertained, my intention is to contribute an article on these interesting specimens to the Society's Journal. The Society is indebted to Mr. S. I. Smith, of Yale College, for the names of several crustaceans described in Dana's and Brandt's elaborate monographs, works which are entirely inaccessible in Canada.

By Mr. Selwyn's request, a specimen of the rare Pennatulid from Burrard's Inlet has been presented to the Museum of McGill University, and a second one will be shortly forwarded to the British Museum.

The Cabinet of Insects belonging to the Society has been partly re-organized during the past summer. All the old and dilapidated specimens have been removed and destroyed, and their place filled, as far as possible, with new and better ones. In every order, the insects obtained on the Island of Montreal, have been kept separate. Large collections have made in the field, during the summer, and the specimens obtained have been properly mounted. Special attention has been paid to the cole-

optera, especially to the aquatic species, and the list of the Montreal beetles has been largely added to. Mr. F. B. Caulfield has also kindly presented us with an extensive series of local species which were previously wanting in our cabinet. Mr. Passmore and myself have also endeavoured to collect as many specimens as possible of the diptera, hymenoptera, hemiptera and orthoptera of the Island of Montreal, and our efforts have been liberally supplemented by Mr. Caulfield and other friends. When a reasonable collection has been obtained, we propose to send the diptera to Baron Osten Sacken, and the hymenoptera to Mr. Cresson, unless Mr. Bowles can find time to work them up here. The orthoptera we hope to study ourselves, and indeed have already examined and identified all those that have been collected so far. One half of the Cabinet has been rearranged, but the coleoptera and lepidoptera remain to be finished. Materials for doing this have been accumulated, and it is hoped that the work will be completed, at least to a certain extent, during the summer. For some time attention has been directed to the collection of those insects which are parasitic on our native mammals and birds. A tolerably complete series of these has been obtained. Mr. Denny's monograph on the anoplura has been purchased, so that, when time will permit, it is hoped that some novel information may be obtained about these so far neglected but very curious insects.

Our local entomologists seem to have devoted most of their energies to the collection and study of the butterflies and moths only, while other orders have received hardly any share of their attention. Almost nothing is known about the two-winged flies of the Island of Montreal, or the bees, wasps, ichneumons, etc., the grasshoppers and the order to which they belong, or the hemiptera or spiders of the same district. Considerable difficulty has been met with in the attempt to preserve the neuroptera and orthoptera, as it was found that the larvæ of dermestes make great havoc among dried specimens in our Cabinet. An alcoholic series of the orthoptera has accordingly been attempted, with fair results, but the preservation of the larger dragon flies has yet to be accomplished.

The remainder of my own private collection of shells and fossils has been imported from England, and some progress has been made in the arrangement and naming of the same. A want of proper cabinets, however, has long delayed the final classification and exhibition of this collection in the Museum.

The number of new specimens of birds or mammals obtained or presented during the past year has been unusually small.

The collection of North American birds' eggs has, however, been largely increased by a donation from J. J. Frothingham, Esq., and by exchanges with Mr. Lechevalier.

Marine invertebrates from the coast of Northern New England have been received, in exchange from Prof. Verrill; and negociations are pending with Mr. Dall, from whom we may expect ultimately to receive some of the products of the seas off Alaska.

In accordance with a vote of the Society to that effect, a report has been published on the Cretaceous Fossils collected by Mr. Richardson in British Columbia, during the season of 1873, and progress has been made with a monograph on some of the Fossils of the Coal-bearing Rocks of the Queen Charlotte Islands.

Two original articles have been contributed to the *Canadian Naturalist*, and two have been read at monthly meetings of the Society, as already stated by the President.

The following financial statement was submitted by the Treasurer, E. E. Shelton:

Dr. THE NATURAL HISTORY SOCIETY in account with E. E. SHELTON, Treasurer. Dr.

1874-75.	
To cash paid J. F. Whiteaves, salary	$400.00
" " S. W. Passmore, "	200.00
" " Foote, commission	29.30
" " for Coal and wood	178.22
" " " Gas	58.94
" " " Water	34.95
" " " City Taxes	59.90
" " " Insurance	42.50
" " " Repairs and petty expenses	100.98
" " " Naturalist, Dawson Bros.' acct.	191.00
" " " Printing and advertising	43.83
" " " Furnace	76.50
" " Interest to Royal Institution	80.00
Balance in Treasurer's hands	509.57
	$2005.69

LIABILITY.

Royal Institution, Balance on Mortgage $1000.00

1874—May 30th.	
By Balance from late Treasurer	$255.94
1874-75.	
By Government grant	750.00
" Cash, Members' Yearly Subscriptions	598.00
" " Museum Entrance Fees	50.50
" " Rent of Lecture Room	209.00
" " realized from Excursion to Belœil	142.25
	$2005.69

Errors and omissions excepted.

[Signed] E. E. SHELTON, *Treasurer.*

Montreal, May 18th, 1875. G. L. Marler, J. H. Joseph, } *Auditors.*

On motion of Prof. R. Bell, seconded by Dr. B. J. Harrington, it was unanimously resolved:

"That the foregoing reports be received, adopted, and printed for distribution among the members."

The thanks of the Society were also voted to the Officers of the past Session.

Principal Dawson moved, seconded by G. L. Marler:

"That the bye-law relating to the election of officers by ballot be suspended, and that A. R. C. Selwyn, F.R.S., &c., be re-elected President."

The motion was carried by acclamation.

Dr. B. J. Harrington and Prof. P. J. Darey having been appointed scrutineers, the following gentlemen were elected Vice-Presidents by ballot:

Vice-Presidents,—Sir W. E. Logan, LL.D., F.R.S.; Rev. A. De Sola, LL.D.; G. Barnston; E. Billings, F.G.S.; Principal Dawson, LL.D., F.R.S.; His Lordship the Metropolitan; C. Robb.

On motion of Mr. Marler, seconded by C. Robb, it was resolved:

"That the formality of balloting be dispensed with, and that the following three officers be re-elected:

Treasurer,—E. E. Shelton.

Corresponding Secretary,—Prof. P. J. Darey, M.A., B.C.L.

Scientific Curator and Recording Secretary,—J. F. Whiteaves, F.G.S.

The Scrutineers then declared the following gentlemen duly elected:

Council,—Prof. R. Bell, Dr. B. J. Harrington, G. L. Marler, J. H. Joseph, Dr. J. B. Edwards, D. A. P. Watt, Rev. Canon Baldwin, D. R. McCord, and James Ferrier, jun.

On motion of Principal Dawson, seconded by Mr. G. L. Marler, it was resolved:

"That Messrs. A. R. C. Selwyn, Dr. B. J. Harrington, R. McLachlan, M. H. Brisette, and Dr. W. Osler be elected a Library and Membership Committee."

DONATIONS TO MUSEUM AND LIBRARY—SESSION 1874-75.

From	TO THE MUSEUM.
Mons. A. Lechevallier.	A series of Bird's Eggs from Florida and California.
E. Murphy, Esq.	A Horned Frog. Phrynosoma cornutum?
Scott Barlow, Esq.	Fine specimen of Amblystoma punctata, Baird, from Spring Hill, Nova Scotia.
Prof. A. E. Verrill.	Two specimens of Cancer borealis from the Coast of Maine.
Miss Cordner.	A young Alligator from Jacksonville, Flor.
Mr. S. W. Passmore.	Water Snake (Nerodia sipedon), Toronto.
	Green Snake (Chlorosoma vernalis) "
Dr. G. P. Girdwood.	Specimens of the Tell-tale Tatler and the Pied Billed Grebe.
J. J. Frothingham, Esq.	A small collection of Canadian bird's eggs, including an egg of the Goshawk from Montreal mountain, and two eggs of the Wild Turkey from Western Canada.
F. B. Caulfield, Esq.	An extensive series of the coleoptera, diptera, hymenoptera, and lepidoptera of the Island of Montreal.
E. J. Major, Esq.	5 Chinese Arrows. 3 Persian do.
	1 Abyssinian Shotel.
	1 Metal Celt, locality unknown.
	Indian Pipe, of Catlinite, brought from the Red River district.
	Indian Stone Pipe, probably from the Plains of the Saskatchewan.
The Geological Survey. per A. R. C. Selwyn, F.R.S. (Director.)	A collection of dried plants from various parts of British Columbia, made by Mr. James Richardson in 1874.
	A valuable series of marine invertebrates from the same region, including, besides about 60 species of shells, fine examples of the great sea pen of Burrard's Inlet (Verrillia Blakei Stearns) in alcohol, also good alcoholic examples of Octopus punctatus Dall, Echidnoceros cibarius White, &c., &c.
	NOTE.—A detailed catalogue of these specimens will be published in an early number of this Journal.

From	TO THE LIBRARY.
John Harris, Esq.	The Circle and the Straight Line, 4 vols. 8vo. cloth.
	Centrifugal Force and Gravitation, 7 vols. 8vo.
	The Science of Ideal Theology as taught by the Bible.
The Trustees of the British Museum.	Catalogue of Birds, vol. 1.
	Hand List of Seals.
	Guide to Exhibition Room.
The Society.	Report of the Entomological Society for the Province of Ontario for 1874.
The Geological Survey.	Report of Progress for 1873.
	Palæozoic Fossils, Vol. 2, Part 1.
The Author.	Manual of Artillery, by General de Peyster.

LIST OF DIURNAL LEPIDOPTERA OF THE ISLAND OF MONTREAL.

By F. B. Caufield.

PAPILIONIDÆ.

1. Papilio asterias Drury.—Not common in the vicinity of the city; more abundant inthe open country. May to end of August.

2. Papilio turnus Linn.—Generally common; end of May to middle of July.

PIERIDÆ.

3. Pieris oleracea Harris.—Not common; May and June. I have not seen an August brood.

4. Pieris rapæ Linn.—Very common, although not so abundant as a few years ago, owing to the attacks of *Pteromalus puparum*. May to end of September. Var. novanglia Scudd., not common, but appear throughout the season.

5. Colias eurytheme Boisd.—Very rare; a male in fine condition, taken last season (1874)by Mr. C. W. Pearson.

6. Colias philodice Godart.—Generally abundant; last season very scarce; June to October; white females very rare; August.

DANAIDÆ.

7. Danais archippus Cram.—Generally common; some years very scarce; May to end of September.

NYMPHALIDÆ.

8. Argynnis cybele Fabr.—Common; end of June to middle of August.

9. Argynnis aphrodite Fabr.—Not so common as the last species; end of June to middle of August.

10. Argynnis atlantis Edwards.—Very rare; I took one example in 1872.

11. Argynnis myrina Cram.—Very common in damp meadows; May, June and August.

12. Melitea phaeton Drury.—Rare; June.

13. Phyciodes Harrisii Scud.—Very rare; taken by Mr. P. Kuetzing.

14. Phyciodes nycteis Doubled.—Rare; July.

15. Phyciodes tharos Boisd. & Lec.—Very common; June to middle of August.

16. Grapta interrogationis Fabr.—Rare; May (hybernated), July to October.

17. Grapta comma Harris.—Common; May (hybernated), end of June to October; var. dryas Edwards, not so common.

18. Grapta faunus Edwards.—Generally scarce; last season (1874) very abundant. May (hybernated), July to October.

19. Grapta progne Cram.—Common; May (hybernated), July to October.

20. Vanessa antiopa Linn.—Very common; end of April and May (hybernated), July to October. Var. Lintnerii, bred by Mr. Pearson, last season.

21. Vanessa milberti Godart.—Not common, being greatly checked by parasites in this locality. I collected over thirty larvæ last season (1874), but only got four butterflies, the remainder being full of small ichneumons. May (hybernated), August and September.

22. Vanessa J. Album Boisd. & Lec.—Not common; end of April and May (hybernated), July to October.

23. Pyrameis huntera Drury.—Generally scarce; August and September. I have not seen hybernated specimens.

24. Pyrameis cardui Linn.—Some years scarce, others common; very abundant last season (1874). May and June (hybernated), August and September.

25. Pyrameis atalanta Linn.—Not common; May (hybernated), end of July to October.

26. Limenitis arthemis Drury.—Not abundant; July and beginning of August.

27. Limenitis disippus Godart.—Common; June to end of August.

SATYRIDÆ.

28. Euptychia eurytus Fabr.—Common in open woods; June.

29. Satyrus nephele Kirby.—Not common; open fields; July and August.

30. Lethe portlandia Fabr.—Not common; July.

31. Pararge Boisduvallii Harris.—Abundant in open grassy swamps; end of June to middle of August.

32. Thecla calanus Hübn.—Generally rare; abundant last season (1874) on blossoms of Asclepias and Sumach; July and August.

33. Thecla mopsus Hübn.—Rare; July and August.

34. Thecla niphon Hübn.—Very rare; taken by Mr. P. Kuetzing.

35. Chrysophanus Americanus Harris.—Generally common; May, June, August and September.

36. Chrysophanus hyllus Cram. (= C. *Thoe* Boisd.) very rare. I took three specimens at Lachine, in August, 1872, and have not met with it since.

37. Lycaena comyntas Godart.—Rare; June, July and Aug.

38. Lycaena lucia Kirby.—Very common; May and June.

HESPERIDÆ.

39. Epargyreus tityrus Fabr.—Common; June and July.

40. Thorybes pylades Scudder. (= T. *Bathyllus* Harris) common; end of May, June and July.

41. Nisoniades brizo Boisd.—Rare; June.

42. Atrytone Zabulon Boisd. (= A. *hobomok* Harris) very common; June. ♀ var. Pocahontas Scudder not common.

43. Anthomaster Leonardus Harris.—Very rare; one specimen taken in 1872.

44. Polites peckius Kirby. (= P. *Wamsutta* Harris) not common; July.

45. Hedone orono Scudder.—Not common; July.

46. Limochores mystic Scudder.—Not common; July.

47. Limochores taumas Fabr. (= L. *Ahaton* Harris) very common; end of June and July.

These are all the species that I have seen from this locality. *Pieris Protodice* was taken at Lachine, some years ago, by Dr. Barnston. *Argynnis bellona* was taken, last season (1874), by Mr. Jack, on the south shore of the St. Lawrence opposite Lachine, and will probably yet be found on the Island of Montreal; and I think additions will be made to the Lycænidæ and Hesperidæ when these groups have been properly worked up.

I have, with two or three exceptions, followed Mr. W. H. Edwards's synopsis in this list, both in classification and nomenclature.

I hope to soon give lists of the remaining families, and would here gratefully acknowledge the assistance given me by those friends who kindly allowed me to study and refer to their material, amongst whom I would especially mention Messrs. Wm. Couper, P. Kutzing, C. W. and G. B. Pearson.—*The Canadian Entomologist.*

A SUMMER STROLL IN ENGLAND.

By G. E. Bulger, F. L. S.

Happening to spend the whole of May and the greater portion of June, last year, at Upnor, in Kent, I enjoyed many a pleasant ramble through the sweet, green lanes and picturesque country-roads of the vicinity—especially in the neighbourhood of Chattenden, where new barracks are in course of construction, almost in the midst of the ordnance plantations—young, tender woodlands, full of delicious, shady nooks, and be-gemmed with thousands of lovely wild flowers.

The portion of Kent I allude to is said to be famous for its primroses and its nightingales—the blossoms of the former appearing in countless myriads very early in the season, and the latter congregating, about the beginning of June, in such number, and singing so lavishly, as to render the spring and summer nights absolutely vocal with their sweet and rapturous strains. The primroses had all but gone before my arrival; but the nightingales were in the full heyday of their happiness, and, during the whole of my stay, they serenaded me nightly with such continuous and wondrous bursts of melody, that it almost seemed to me as if the little birds could never tire, or that their sole mission upon earth was to sing until they died.

One bright and glorious day, early in June, I wandered out in the direction of Chattenden, along a lovely and secluded road, almost hidden between luxuriant hedgerows, in which the bloom and fragrance of the hawthorn had but recently given place to the frail, soft beauty of the delicate, wild rose; though, ever and anon, an elder-bush flaunted its broad corymbs of white flowers amidst the sweeter and more attractive, though less conspicuous, blossoms of its modest and blushing neighbour.

On either side of this charming pathway, the country presented a succession of smiling meadows and picturesque woodlands—typical of that fair and gentle pastoral beauty which seems to be the especial attribute of sweet, yet rich and peerless England: the former intensely green with the bright verdure of early summer, and spangled with millions of gay flowers, amongst which the white stars of the great moon-daisy (*Chrysanthemum leucanthemum*) were conspicuously abundant.

Hedge-plants did not seem to be generally in bloom, though, here and there, the pale petals of the blackberry showed themselves amidst the tangled bushes, and purple vetches (*Vicia cracca et sativa*), the wild chervil (*Chærophyllum sylvestre*), crucifers of several genera, with buttercups of at fewest two species (*Ranunculus bulbosus et acris*), and the purple flowers of the common mallow (*malva sylvestris*) peeped out from the long grass and lower herbage: while, at the edges of the fields, close to the road, I found blossoms of the common gromwell (*Lithospermum officinale*), the dogwood (*Cornus sanguinea*), a pale lilac variety of the large bittercress (*Cardamine amara*), the lesser stitchwort (*Stellaria graminea*), the common agrimony (*Agrimonia eupatoria*), and the great, rank goutweed (*Ægopodium podagraria*); as well as, much to my surprise, the already developed seed-balls of the yellow goat's beard (*Tragopogon pratense*).

Of birds, I met with few. The modest and confiding hedge sparrow (*Accentor modularis*), harmless, unobtrusive little dweller by the road-side, crept out now and then from the shelter of his leafy home to look about him; a few stray robins and thrushes piped their sweet songs occasionally from the trees and copses close by; but the woods and meadows were, for the most part, silent, and even the joyous skylark seemed to have gone to rest for a time. Later in the day, however, I heard several cuckoos, saw a flock of starlings, and disturbed a magpie from a thicket, out of which he darted with a precipitancy that looked very like conscious guilt, and suggested the idea of a culprit endeavouring to escape from the consequences of some recently committed crime.

Insects did not strike me as being abundant, though the orange-tip butterfly (*Euchloe cardamine*) seemed common enough wherever I went, as well as the small cabbage-white (*Pieris rapæ*); and bees and wasps of several species were humming and buzzing about amongst the flowers, while numbers of the ethereal-looking, but ferocious, blue dragon-flies, were continually darting through the air in pursuit of the unhappy little creatures on which they prey. I found one brown, hairy caterpillar, with black rings at the joining of the segments, which appeared to me to resemble very much the larva of the moth (*Lasiocampa rubi*); but, on this point, I can give no reliable opinion.

. . . . . .

Returning to Upnor, about four o'clock, I found the sun so powerful that I was really glad to get under shelter of the woods, which were fresh and pleasant, as usual, and gay with wild flowers. Amongst these, the showy blossoms of the red lychnis (*Lychnis diurna*) were very conspicuous—some pale rose in colour, and others of a rich carmine; but, here and there, their glory was eclipsed by the effulgence of the field poppy (*Papaver rhœas*), which was then beginning to bloom abundantly. The strange and beautiful luminous glow which surrounds these brilliant flowers under certain conditions, did not present itself to my senses on the occasion I refer to, though the vivid hue of the scarlet corollas was very striking, and stood out from the green gloom of the woods in strong relief. I found both the common and black bryonies (*Bryonia dioica et Tamus communis*) in blossom; also *Sherardia arvensis*, the stink mayweed (*Anthemis cotula*), *Ranunculus repens et arvensis*, *Fumaria officinalis* sparingly; *Veronica chamædrys*, *Myosotis arvensis*, *Polygonum maritimum*, *Stachys sylvatica*, *Convolvulus arvensis*, *Geranium dissectum*, and other common plants; as well as several grasses, which, although very lovely to the eye, have a most unpleasant influence, in summer time, upon those who suffer, as I do, from hay asthma.

Ever and anon, I heard the cuckoo during my ramble homewards, and the soft, mournful notes of the wood-pigeon (*Columba palumbus*) came bubbling up at intervals from the leafy recesses of the neighbouring groves, while the beautiful, little yellow-hammer (*Emberiza citrinella*) constantly obtruded himself and his pleasant whistle upon my notice, as I lingered amongst the many attractions of the sweet, young woods.

Yours truly
R. E. Logan

SIR WILLIAM EDMOND LOGAN.*

On the 22nd of June, at Castle Malgwyn, Llechryd, South Wales, Canada's veteran geologist passed from his labours. For several years his health had been failing, and he felt more and more the need of rest and change of climate. Accordingly, in August, 1874, he crossed to the mother country, intending to pass the winter there, and then to return to his work in the spring. But rest and a more genial clime were unavailing, and now—kindest of friends, most indefatigable of workers for science and for his country—he is no more! We shall never again hear the ring of his hammer; but time cannot efface its marks, and deep-chiselled in the face of Cape Eternity, the generations of the future shall read the names—LOGAN and LAURENTIAN.

William Edmond Logan was born at Montreal, in 1798. He was of Scottish parentage, and his father, after a residence of many years in Canada, returned to Scotland, and purchased an estate near Stirling, known as Clarkstone. His education was begun at Mr. Skakel's school, in this city, and completed at the High School and University of Edinburgh.

On leaving college he betook himself to mercantile pursuits, and we find that in 1818 he entered the counting-house of his uncle, Mr. Hart Logan, of London. Here he remained for about ten years, and here, it is said, he first became fond of geology, making geological excursions into the country whenever opportunity afforded.

In 1829, he paid a visit to Canada; but, returning the same year, took up his residence at Swansea, in South Wales, where he was appointed manager of a copper-smelting establishment, and of coal mines, in which an uncle of his was interested. In 1834, he made a tour through France and Spain, visiting many of the mines in the latter country, and making many observations on the geology of the regions through which he passed. In 1838, his uncle dying, Mr. Logan resigned his position at Swansea. But the nine years he spent here were well-spent years; for not only had he gained a practical knowledge of

* Obituary notice read before the Natural History Society, October 25th, 1875.

mining and metallurgy, which afterwards proved of the greatest value to him, but had done a large amount of very excellent geological work—work which caused Dr. Buckland, of Oxford, to say of him, "He is the most skilful geological surveyor of a coal-field I have ever known." During his stay at Swansea, he was an active worker for the interests of the Royal Institution of South Wales. He was Honorary Secretary and Curator of the geological department, and the Institution is indebted to him for valuable collections of minerals and metallurgical products, besides books, drawings and laboratory apparatus. The whole of his geological work in South Wales he placed gratuitously at the disposal of the Ordnance Geological Survey of Great Britain, and it was not only gladly accepted, but published "without alteration," and made the basis of future work in that region. Concerning it, Sir H. T. De la Beche afterwards wrote as follows :

"Prior to the appearance of the Geological Survey in that part of the country, Mr. W. E. Logan had carefully investigated it, and at the meeting of the British Association for the Advancement of Science, held at Liverpool in 1837, he exhibited a beautifully executed map of it.

"The work on this District being of an order so greatly superior to that usual with geologists, and corresponding in the minuteness and accuracy of its detail, with the maps and sections executed by the Ordnance Geological Survey, we felt desirous of availing ourselves of it, when Mr. Logan most handsomely placed it at our disposal. Having verified this work with great care, we find it so excellent that we shall adopt it for that part of the country to which it relates, considering it but fair and proper that Mr. Logan should obtain that credit to which his labours so justly entitle him.

"His sections are all levelled and measured carefully with proper instruments, and his maps are executed with a precision only as yet employed, except in his case, on the Ordnance Geological Survey ; it being considered essential on that survey, for the right progress of geology, and the applications to the useful purposes of life, that this accuracy and precision should be attained."

In 1840, Logan read a paper before the Geological Society of London, in which he explained, for the first time, the true relation of the *Stigmaria* underclays to the overlying beds of coal,

shewing that the underclay was the soil in which the plants grew which were afterwards converted into coal. Of the 100 thick and thin coal-seams in the South Wales coal-field, he found that not a single one was without an underclay, and the inference appeared to be that there was some essential connection between the production of the one and the existence of the other. "To account," said he, "for the unfailing combination by drift, seems an unsatisfactory hypothesis; but whatever may be the mutual dependance of the phenomena, they give us reasonable grounds to suppose that in the *Stigmaria ficoides* we have the plant to which the earth is mainly indebted for those vast stores of fossil fuel which are now so indispensable to the comfort and prosperity of its inhabitants."

So much did he become interested in this subject that in the following year (1841) he crossed to America, and visited the coal-fields of Pennsylvania and Nova Scotia, in order to ascertain whether the same conditions existed there. Such he found to be the case; and in the following Spring he read an interesting paper before the Geological Society, the object of which, to use his own words, "was to state the occurrence immediately below the coal-seams of America of the same *Stigmaria* beds as had been observed below those of South Wales, and to shew the importance of this prevailing fact." Shortly after his return from America, he also visited coal-seams in the neighbourhood of Falkirk, Scotland, there too finding the *Stigmaria* clays beneath the coal.

It was during his visit to Nova Scotia, in 1841, that he discovered in the Lower Coal measusures of Horton Bluff the footprints of a reptilian animal—a discovery which perhaps failed to attract as much attention as it deserved, although it was the first instance in which any trace of reptiles had been detected as low down in the geological scale as the Carboniferous. The winter of 1841–42 was also spent in Canada, and the facts obtained for a paper on the packing of ice in the St. Lawrence, which was subsequently read before the Geological Society of London.

Such, briefly, was the career of Logan previous to his appointment as Director of the Geological Survey of Canada. Already he had acquired a reputation in Britain as a geologist, and had given himself the best of trainings for the work upon which he was about to enter on this side of the Atlantic. But what was meantime passing in Canada?

"In January, 1832, a petition from Dr. Rae, praying for pecuniary assistance in prosecution of a geological and statistical survey of the province, was sent down by message to the Legislative Assembly, with a favourable recommendation from his Excellency Sir John Colborne, Lt. Gov. of Upper Canada. It was read and referred to the committee of supply, but not considered.

"In February, 1836, on the motion of Mr. W. L. Mackenzie, seconded by Mr. Durand, Messrs. R. G. Dunlop, Gibson and C. Duncombe were named a select committee to consider and report on a plan for a geological survey of the Province. Three hundred copies of this report were ordered to be printed, and it was referred to the committee of supply, but was not considered.

In November, 1836, on the motion of Mr. R. G. Dunlop, seconded by Col. Prince, the house went into a committee of the whole to consider the expediency of a geological survey, and, on their report being received, it was resolved that an address should be presented to His Excellency the Lieut. Governor (Sir F. B. Head), to ascertain whether there were any means at his disposal to effect a geological survey of the Province. The address was ordered to be drafted, but was not reported.

"In December, 1836, Mr. R. G. Dunlop gave notice that he would move an address to His Majesty for a grant of wild lands to defray the expense of a geological survey of the Province, but no address was presented.

"To Lord Sydenham, who well appreciated the importance of an examination into the mineral resources of Canada, the country is indebted for the commencement of the geological survey which has been instituted.

"In July, 1841, in the first United Parliament, a petition from the Natural History Society of Montreal, praying for aid to carry out a systematic geological survey of the Province, was presented by Mr. B. Holmes. It was referred to a select committee consisting of Messrs. Holmes, Neilson, Quesnel, Merrit, and the Hon. Mr. Killaly, but it was not reported on. A similar petition was presented by Mr. Black, from the Literary and Historical Society of Quebec, which was read. The government took up the matter, and on the motion of the Hon. B. Harrison, the sum of £1500 sterling for the purposes of a survey was introduced into the estimates."*

* From Scobie's Canadian Almanac for 1851.

Lord Sydenham dying in 1841, it fell to his successor, Sir Charles Bagot, to appoint a Provincial Geologist. Sir Charles referred the matter to Lord Stanley, Secretary of State for the Colonies, and His Lordship, on recommendation of Murchison, De la Beche, Sedgwick, and Buckland, offered the position to Mr. Logan in the spring of 1842.

Logan was now thoroughly in love with geology, and seeing in Canada the grandest of fields for original research, at once accepted. Still he well understood the difficulties which lay before him, and shortly afterwards addressed the following words to De la Beche: "You are aware that I have been appointed by the Provincial Government of Canada to make a Geological Survey of that Colony. The extent and nature of the territory will render the task a most laborious one; but I am fully prepared to spare no exertion of which I am capable to render the work, when it is completed, satisfactory to those who have instituted the examination and creditable to myself ..... No one knows better than yourself how difficult it would be for one person to work with effect in all the branches of so extensive a subject. To carry out the field-work with vigour, to reduce all the sections with the requisite degree of accuracy, and map the geographical distribution of the rocks, to collect minerals and fossils, and to analyze the one, and by laborious and extensive comparisons, to determine the geological age of the other, is quite impossible without a proper division of labour..... In Canada, all the expensive means of palæontological comparison have yet to be brought together. There is no arranged collection of fossils, and no such thing as a geological library to refer to."

Arriving in Canada late in August, 1842, Logan devoted several months to making a preliminary examination of the country, and to collecting information with regard to the topographical work which had been accomplished. This was done entirely at his own expense. In December, he returned to England to fulfil engagements there, but came out again in the following spring, During his visit to the old country, he was so fortunate as to secure the services of Mr. Alexander Murray, a gentleman who afterwards proved himself an invaluable assistant and friend, and who has contributed largely to our knowledge of the geology of Canada, and, more recently, to that of Newfoundland.

Reaching Halifax on the 20th of May, Logan spent several weeks in examining portions of the coal-fields of Nova Scotia and New Brunswick, and it was at this time that he made his section of the Coal Measures at the South Joggins, which, as has been truly said, is "a remarkable monument of his industry and powers of observation." It gives details of nearly the whole thickness of the Coal formation of Nova Scotia, or 14,570 feet, including 76 beds of coal and 90 distinct *Stigmaria* underclays. Shortly after his visit to the Joggins, he wrote to a friend as follows: "I never before saw such a magnificent section as is there dispayed. The rocks along the coast are laid bare for thirty miles, and every stratum can be touched and examined in nearly the whole distance. A considerable portion has a high angle of inclination, and the geological thickness thus brought to view is very great. I measured and registered every bed occurring in a horizontal distance of ten miles, taking the angle of dip all the way along." And again, in a letter to De la Beche written in the spring of 1844, referring to the Joggins section, he says: "Since my return from field-work, I have reduced all the measurements and made out a vertical column. It occupies fifty-four pages of foolscap, closely written, and you will be astonished at the details in it."

Reaching Gaspé early in July, the summer and autumn were spent in making an examination of the coast, while Mr. Murray was at work in the Upper Province, examining the country between Lakes Huron and Erie. The Gaspé peninsula had been selected by Mr. Logan as the field for his first operations, as it was thought that outlying patches of the Carboniferous might be found to exist there, and the government was especially anxious to ascertain whether there was any truth in the reported occurrence of coal.

The following season, the work in Gaspé was continued, the Director being this time accompanied by Mr. Murray, who, in 1845, again carried on the work, while Mr. Logan was engaged in explorations on the Upper Ottawa and Mattawan. Altogether, during the three seasons, 800 miles of the Gaspé coast were examined, and several sections made across the peninsula, from the St. Lawrence to Bay Chaleur. No coal was found, but many geological facts of importance were accumulated, and a large amount of topographical work accomplished in what was previously almost a *terra incognita*.

"Living the life of a savage, sleeping on the beach in a blanket sack with my feet to the fire, seldom taking my clothes off, eating salt pork and ship's biscuit, occasionally tormented by mosquitoes,"—such is the record which Logan has left us of his Gaspé life, the foretaste of what was to be endured for many years. From early dawn till dusk he paced or paddled, and yet his work was not finished, for while his Indians—often his sole companions—smoked their pipes round the evening fire, he wrote his notes and plotted the day's measurements.

To give details of his work during the many remaining years of his life would be to write a book; and all that we can do here is to trace briefly what his movements were, at the same time calling special attention to those of his labours which have given him a world-wide fame.

The summer of 1846 found him studying the copper-bearing rocks of Lake Superior. These he shewed to consist of two groups of strata, the "upper" and the "lower," the latter of which was seen at Thunder Bay to rest unconformably upon chloritic slates belonging to an older series, to which the name of Huronian was subsequently given. This older set of rocks, which he had already observed, in 1845, on Lake Temiscamang, he had ample opportunity of studying in 1848, when he devoted several months to an examination of the Canadian coast and islands of Lake Huron, where the formation attains—as shewn by Murray—a thickness of 18,000 feet.

The seasons of 1847 and 1849, and a portion of that of 1848, were employed in studying the rocks of the Eastern Townships. Part of these were shown to be a prolongation of the Green Mountains of Vermont, and to consist of altered Silurian strata instead of "Primary strata," as was previously supposed by American geologists. In 1849 also, a short time was spent in an examination of the rocks about Bay St. Paul and Murray Bay, where coal had been reported to exist. The member for Saguenay county had previously made application to the Legislature for means to carry on boring operations in the vicinity of Bay St. Paul, but before his request was granted it was deemed advisable to obtain the opinion of the Provincial Geologist. By this means the Government was saved a large and useless expenditure of money.

In 1850 an examination was made of the gold-bearing drift of the Chaudière, and the auriferous district found to extend over

an area of between 3,000 and 4,000 square miles. Most of the year, however, was devoted to the collection of specimens for the London Exhibition of 1851, at which Mr. Logan acted as Juror. His visit to England at this time must have been for him an agreeable change. After a lapse of eight years to meet again with men like De la Beche, Murchison, and Lyell, to hear from their own lips of the strides which science had been making, and in turn to tell of all that he had himself seen and done; surely this was a treat that none but the scientific man can understand who has long been well-nigh deprived of the society of brother scientists. For him, however, there was little relaxation from labour, for he toiled early and late in order that the Canadian minerals might be displayed to the best advantage. And every one knows the result—the collection elicited univeral admiration, and Mr. Logan received a highly complimentary letter of thanks from the Prince Consort, and was elected a Fellow of the Royal Society, his name having been proposed by Sir Roderick Murchison.

Returning to Canada in August, before the close of the Exhibition, his explorations were renewed with undiminished vigour, and the remainder of the season devoted to an examination of the rocks in the county of Beauharnois, where the Potsdam sandstones had afforded those curious tracks of crustaceans to which Owen gave the name of Protichnites, and to a further study of the Chaudière gold region. During the winter he again visited England to attend to the distribution of a portion of the Exhibition collection which was to be left there, and see to the return of the remainder.

In 1852 an examination was made of a strip of country on the north side of the St. Lawrence, extending from Montreal to Cape Tourmente below Quebec. The distribution of the fossiliferous rocks was accurately determined, and several excursions made into the hilly "metamorphic country" to the north. In his report on this season's operations, published in 1854, Logan for the first time designated the rocks comprising these hills as the "Laurentian series," substituting this for "metamorphic series," the name which he had previously employed, but which, as he says, is applicable to any series of rocks in an altered condition.

The following season was spent among the Laurentian hills of Grenville and the adjoining townships, a field which proved so attractive that he afterwards returned to it in 1856 and 1858.

Nearly the whole of 1854 was occupied in making preparations for the Exhibition which was to take place at Paris in the following year, and to which Mr. Logan was to go as one of the Canadian Commissioners. It was in the autumn of 1854 also, that a select committee was appointed by the Canadian Government to inquire into the best method of making the information acquired by the Geological Survey more readily accessible to the public. A lengthy report on the subject—indeed on the entire working of the Survey—was published, and the evidence which it contains is of a most flattering character, both as regards the Director and those associated with him.

Then came the Paris Exhibition of 1855, at which the representation of the economic minerals of Canada was so complete and the arrangement so admirable that the collection attracted universal attention. This in itself Logan would have regarded as amply repaying him for his trouble, but greater honour was in store for him. The Imperial Commission presented him with the grand gold medal of honour, and the Emperor of the French made him a Chevalier of the Legion of Honour. Early in the following year (1856) he was knighted by Queen Victoria, and received from the Geological Society of London the Wollaston Palladium Medal in recognition of his distinguished labours in geology. Long previous he had won the confidence and esteem of his fellow-countrymen in Canada, but this seemed to be a fitting time to testify to him their appreciation of his worth. Accordingly, on his return to Montreal, the citizens presented him with a testimonial on which were engraved the words:

"In commemoration of his long and useful services as Provincial Geologist in Canada, and especially his valuable services in connection with the Exhibition of all Nations in London in 1851, and in Paris in 1855, by which he not only obtained for himself higher honor and more extended reputation, but largely contributed in making known the natural resources of his native country."

The Natural History Society of Montreal presented him with an address, and made him an honorary member, while the members of the Canadian Institute of Toronto, of which Sir William was the first President, had his portrait painted and hung up in their hall. They also presented him with an address expressive of their affectionate esteem and respect. Sir William's reply to this was so full of feeling, and so highly characteristic,

that we give a portion of it: "Whatever distinctions," said he, "may be bestowed on us at a distance, it is upon the respect, esteem, and confidence shewn us at home, that our happiness and satisfaction must chiefly depend. I can assure you with sincerity that the honor conferred upon me when you elected me the first President of the Institute, was one highly prized, although the circumstances of a distant domicile and the intent pursuit of the investigations with which I am charged, rendered it extremely difficult for me to be of much use in your proceedings. . . . . It is a fortunate circumstance for me that my name should be connected with an act of grace on the part of Her Majesty, which serves to confirm your feeling in regard to the fact that as Canadians we enjoy a full share in the honors and privileges of British subjects. And I am proud to think that it was perhaps more because I was a Canadian, in whom the inhabitants of the Province had reposed some trust, that the honor which has been conferred upon me by Her Majesty was so easily obtained. That I am proud of the honors which have been bestowed upon me by the Emperor of France, in respect to my geological labors, and also by my brother geologists in England, there can be no doubt. But I have striven for these honors because I have considered they would tend to promote the confidence which the inhabitants of the Province have reposed in me, in my endeavors to develop the truth in regard to the mineral resources of the Province; and in this work none could have been more interested in my success than the members of this Institute." *

In August, 1857, the American Association for the Advancement of Science held its annual meeting in Montreal, and for several months previous Sir William was hard at work getting his museum in readiness to receive his brother geologists. Owing largely to his untiring exertions, the meeting was a most successful one. He himself read two interesting papers, one on the "Huronian and Laurentian Series of Canada," and another on the "Sub-division of the Laurentian Rocks of Canada." After the business of the Association was concluded, accompanied by Professor Ramsay, who had come over to represent the Geological Society of London, and Prof. Hall, he made a Geological tour through New York State. Returning from this

* Can. Journal, New Series, Vol. 1, p. 404.

trip, he spent the autumn months among the Laurentian rocks of Grenville. Here too, as already mentioned, he continued to work during the season of 1858.

For several years after this, his time was much taken up with the preparation and publication of the *Geology of Canada* and its accompanying Atlas, the former of which appeared in 1863, and the latter in 1865. Before these could be completed, however, many facts had to be added to the stock already obtained, and besides a large amount of geological work among the Laurentian rocks of Grenville and the rocks of the Eastern Townships, a personal examination of many parts of the country, as well as of portions of the New England States, was rendered necessary.

In 1862, Sir William was again present, in the capacity of Juror, at the London International Exhibition, and again displayed a large and interesting collection of economic minerals. Another opportunity of seeing his scientific friends in Britain was also afforded him in 1864, when he went to London to superintend the engraving of the Atlas already mentioned. In 1866, a geological collection was again prepared for the Paris Exhibition of 1867, and Sir William worked so closely in getting up a geological map to accompany it that he is said to have nearly ruined his eyesight. 1868 found him once more on this side of the Atlantic, hard at work in the Pictou coal field, and the results of this season's work constitute the last of his reports. In 1869, he resigned his appointment to Mr. Selwyn, the present Director of the Survey.

The few remaining years of his life were occupied chiefly with a study of the rocks of the Eastern Townships and portions of New England; but, unfortunately, the conclusions at which he arrived concerning them were not published.

No man has done as much as Sir William Logan to bring Canada before the notice of the outside world, and no man is more deserving of being held in remembrance by the people. Just as statesmen or generals have risen up at the moment of greatest need to frame laws or fight battles for their country, so Sir William appeared to reveal to us the hidden treasures of Nature, just at a time when Canada needed to know her wealth in order to appreciate her greatness. For rising nations require to know what their resources are. He possessed rare qualities—qualities, which, combined, eminently fitted him for his work.

He was strong in body, of active mind, industrious and doggedly persevering, painstaking, a lover of truth, generous, possessed of the keenest knowledge of human nature, sound in judgment, but always cautious in expressing an opinion.

He belonged to that school of geologists—unfortunately not so numerously represented as it ought to be—whose motto is, "Facts, then theories," and was wholly above rasping down facts to make them fit theories. As a consequence, he rarely had to un-say what was once said; and this is why he so thoroughly gained the public confidence. So long as he felt that he was in the right, he held to his own views as tenaciously as did ever any true Scot; but if shewn to be in the wrong, he knew how to surrender gracefully.

Those who have clambered with him over our log-strewn Laurentian hills know well what were his powers of endurance. He never seemed to tire, never found the days long enough. His field-books are models of carefulness, replete with details, and serve as an example of the painstaking way in which he did all his work. They were written in pencil, but regularly inked in at night, when the camp fire was often his only light. In addition to his field-book proper, he frequently kept a diary, and delighted to jot down little every-day occurrences, or sketch objects of interest—for the hand that could so well wield a hammer, could also guide a pencil and produce drawings of no mean artistic skill. His descriptions of his backwoods experiences are often very amusing, and we cannot resist giving a specimen. He had been travelling through the forest for two months and had suddenly come upon the house of a settler called Barton, whose good wife was justly alarmed when Sir William and party entered her dwelling. Sir William describes his appearance, on this occasion, as follows:—"We are all pretty-looking figures. I fancy I cut the nearest resemblance to a scarecrow. What with hair matted with spruce gum, a beard three months old, red, with two patches of white on one side, a pair of cracked spectacles, a red flannel shirt, a waistcoat with patches on the left pocket,—where some sulphuric acid, which I carry in a small vial to try for the presence of lime in the rocks, had leaked through,—a jacket of moleskin, shining with grease, and trowsers patched on one knee in four places, and with a burnt hole in the other; with beef boots—Canada boots, as they are called—torn and roughened all over with scraping on the stumps

and branches of trees, and patched on the legs with sundry pieces of leather of divers colours; a broad-brimmed and round-topped hat, once white, but now no colour, and battered into all shapes. With all these adornments, I am not surprised that Mrs. Barton, speaking of her children, and saying that here was "a little fellow frightened of nothing on earth," should qualify the expression by saying, "but I think he's a little scared at *you*, Sir."

It was not alone in the field that Sir William was busy. His office work was often most arduous, and during the earlier years of his directorship, in addition to preparing his annual report, he even kept the accounts, entering every item of expenditure, so that he could at any time shew exactly how every penny of the public money placed at his disposal had been spent. He also tells us that, with his own hands, he made, at that time, four manuscript copies of the Annual Report of Progress, often reaching more than one hundred printed pages—one copy for the Government, one for the House of Assembly, one for the Legislative Council, and one for the printer.

His manner of living was simple as it was solitary. Like his four brothers, he never married, nor does he seem to have formed many intimate friendships. Still every one who knew him loved him and respected him, and if you go the length and breadth of all the land, you will everywhere hear his praises, alike from rich and poor.

He peculiarly possessed the power of inspiring others with his own enthusiasm; not only those in his employ, but even uneduc ted farmers and backwoodsmen—men who, as a rule, are rather sceptical about the advantages to be derived from geology.

Though possessed of private means, he spent little upon himself; not that he was parsimonious, but he cared not for fashion or luxury. But with him Science never pleaded her needs in vain. The first grant of the Legislature, to make a geological survey of the Colonies, was £1,500—an amount which, Sir William quaintly remarked, was but a drop of what would be required to float him over twenty-five degrees of longitude and ten of latitude. This was, of course, very soon spent, and not only this, but at the end of the second year the Survey was £800 in his debt, and he had no guarantee whatever that his money would be returned to him. Since then the Survey has been constantly indebted to him for books, instruments, and other aids, and the building on St. James street, now used for office

purposes, was built by him, two years ago, and rented to the Government for about half the amount which he could have obtained from other tenants. To Logan also, McGill University owes much; for, in 1864, he founded and endowed the "Logan Gold Medal" for an honor course in geology and natural science, and, in 1871, gave $19.000, which, together with $1,000 given by his brother, the late Mr. Hart Logan, forms the endowment of the "Logan Chair of Geology."

Since resigning his position as Director of the Geological Survey, he has carried on explorations at his own expense, and at the time of his death arrangements had been nearly completed for putting down a bore-hole in the Eastern Townships, at a cost of $8,000; as he thought that this would enable him to prove the truth of his views with regard to the age of the metamorphic rocks there.

Every one knows how nobly he acted when asked by the East India Company, in 1845, to make an examination of their territory for coal. The inducements were strong, and no one could have blamed him for giving up his Canadian appointment under the circumstances. But listen to what he says about it: "The field of research was new, and India a country attracting much more European attention than this. I felt perfectly certain the investigation would lead to a very extended reputation. The salary offered me was more than double what I have here, an efficient staff was to be provided, with all kinds of those aids which an Indian Government could so readily afford. But, influenced by a rooted attachment to this country, and feeling that perhaps some favor have been extended to me, because I am a Canadian, I did not accept the offer." *

Sir William was the first to give us any definite information about those wondrous old Laurentian rocks which form the backbone of our continent. He shewed us that they were older than the Huronian, and that they consisted of a great series of metamorphosed sedimentary rocks, which are divisible into two unconformable groups, with a combined thickness of not less than 30,000 feet. The great beds of limestone which he found in the lower series, the plumbago, the iron ores, the metallic sulphurets, all seemed to point to the existence of life in the Laurentian days; but the discovery of *Eozoon Canadense* made

* Report of the Select Committee on the Geological Survey, p. 22.

conjecture give place to certainty. Now we *know* that the world of that far-off time was not a lifeless world. Life, whatever that may be, had been joined to matter.

The first specimens of *Eozoon* were found by Dr. James Wilson, of Perth; but at the time of their discovery were regarded merely as minerals. In 1858, however, Mr. J. McMullen, of the Geological Survey, discovered other specimens, the organic origin of which so struck Sir William that in the following year—four years before their true structure and affinities were determined by Dawson and Carpenter—he even exhibited them as fossils at the meeting of the American Association.

In widely extending our knowledge of the early geological history of the earth, Sir William has done a great work; indeed this may be regarded as his greatest work. Its importance has everywhere been recognized, and the name Laurentian, which he chose for the rocks at the bottom of the geological scale in America, has crossed the Atlantic, and is now applied to the homotaxial rocks of Europe. Sir Roderick Murchison, who dedicated the fourth edition of "Siluria" to Sir William Logan, even substituted Laurentian for "Fundamental Gneiss," the name which he had given to the rocks of the West Highlands of Scotland. "I at first," says Murchison, "termed them 'Fundamental Gneiss,' and soon after, following my distinguished friend, Sir William Logan, I applied to them his term, 'Laurentian,' and thus clearly distinguished them from the younger gneissic and micaceous crystalline rocks of the Central and Eastern Highlands, which were classed as metamorphosed Lower Silurian."

Logan was not a voluminous writer, and during the latter years of his life writing was a great effort to him. Occasional papers from his pen have appeared in the *Transactions of the Geological Society* of London, in the *Canadian Naturalist* and the *Canadian Journal*, and some of these have already been referred to; but most of what he has written is to be found in the *Reports of Progress* annually submitted to the Government, and in that invaluable book, the *Geology of Canada*, which is, to a large extent, a digest of what is contained in the reports published previous to 1863. He sometimes expressed himself quaintly, but everything he wrote is clear and exceedingly concise.

In addition to being a Fellow of the Royal Society and of the Geological Societies of London and Paris, he was a member

of numerous other learned societies both in Europe and America. At the time of his death, and for many years previous, he was one of our Vice-Presidents; but though frequently solicited to accept the office of President, he always declined,—not on account of any lack of interest in the Society, but because he felt his time was too fully occupied to permit of his successfully discharging the Presidential duties. We have already alluded to some of the medals which were awarded to him; but it may be mentioned that altogether he was the recipient of more than twenty, including two from the Royal Society.

And now, in concluding, let me say to you, my friends, if you would do honour to the memory of that noble old man, who fought so long, so bravely, for his country, for science, for you, then honour the cause for which he fought: strive with all your might to advance the interests of that cause, and to raise up a superstructure befitting the solid foundation which Logan has laid. He himself even hoped to build the superstructure; but his anticipations were not realized, for life was not long enough, and we must take up the mantle which he has dropped.

B. J. H.

NATURE AND THE BIBLE.

This is the title of a series of lectures delivered, last winter, by Dr. Dawson, the Principal of McGill College, before the Union Theological Seminary of New York. These lectures were founded by the late Professor Morse, after the plan of the Bampton and Boyle lectures. The general subject of the lectureship is defined to be "the relation of the Bible to the sciences." Dr. Dawson has selected some of the points of contact which are now most debated, and has treated them in six lectures. These are printed in a handsome volume, and form a handy repertory of replies to many of the current attacks upon the Christian theory of the system of nature.

At the very outset, there is claimed for the naturalist the fullest freedom in pursuing the methods of his own science, untrammelled by the methods of theology. Otherwise the testimony of each to other would be valueless; but if, in strictly following his own path, the naturalist arrives at results which are in accordance with statements given in Genesis, and if these statements are many thousand years in advance of the knowledge current at the time when the Pentateuch was committed to writing, it will of course follow that Moses had sources of information not accessible to ordinary historians. As to whether Moses himself committed these books to writing, or as to the manner in which his information was obtained, neither point is necessary to be considered in the argument of these lectures.

The lecturer points out that a complete revelation of the natural sciences, in advance of the requirements of mankind, could not be expected. All that can be expected is an avoidance of those errors which were current at the time, and also, when physical phenomena are recorded as facts, that the record, although scanty, should not teach anything which clashes with any certain results arrived at by other methods. The Mosaic books commence with a cosmogony. All other religions do the same. The Buddhist, the Brahmin, and the Greek all required a theory of the origin of the world. Even the roving Cree of our prairie provinces has a legend of the Kitchi-Manitou who

formed the earth and the sky. The Confucian Chinaman and the positivist Fortnightly Reviewers, similar products of advanced thought and culture, are alone careless of the past and future—content with the barren philosophy of utilitarianism. These are stunted forms of thought—curious and interesting as are those clipped and trimmed trees sometimes seen in royal gardens—but the natural and healthy instinctive intelligence of mankind is ever questioning as to the "why?" the "whence?" and the "whither?" of our universe. Those who would deprive us of our metaphysics, and whose whole hope for the cure of the world is placed in positivism, universal education, and competi tive examinations, may look to China for their ideal land of culture and intelligence.

Dr. Dawson justly dwells with considerable emphasis upon the fact that the recent discoveries of science concerning the identity of light, heat and motion explain some parts of the Mosaic record which were before obscure. For instance, the announcement of the creation of light before the sun is said to have existed, is a remarkable instance of the avoidance of a very natural error, and the gradual development of life upon the globe as related by Moses, runs in the same course with the story of the fossiliferous rocks. Upon such points as these Dr. Dawson is one of the first living authorities. He stands among a very few, at the very summit of this branch of science. His knowledge is not the knowledge of the closet only, but the knowledge of a man who has won it by hard labour and patient investigation in the field, the forest, and the mine; and to the study of the facts of natural science the whole of a busy life has been devoted. When, therefore, as in these lectures, he declares that no antagonism exists between the two records, we know of no man more entitled to a patient hearing.

Although we are disposed to allow full credit to the lofty monotheism of the Hebrew mind, as indicating a belief in the unity and uniformity of natural law, we are not disposed to acquiesce in the lecturer's disparaging reference to the "crudities of Greek philosophy." It seems to us that the secret of the universe cannot be discovered either by the theological method of the Hebrew, by the subjective method of the Greek, or by the objective method of modern science alone. All three are necessary, and all three find their synthesis in Christian science. The mind is oppressed by the elaborate ritual and stern sacrificial

system of the Hebrews, where the moral phase of our nature is alone developed. As Mr. Gladstone well puts it, "the beauty and joyousness of life was entrusted to the Greeks as their mission," while we moderns dwell mainly upon its utilities. The teaching of Nazareth gathered up the truth from all sides, so the Christian philosopher may be at once as monotheistic as Joshua, as pantheistic as Spinoza, and as utilitarian as Bentham. It will require more than one age or one race to show the whole design of God, and the Hebrews are but one colour, dominant though it may be, in the glorious and intricate web which He is now weaving on the "loom of time." Crude though many of the Greek speculations were, we owe to them our intellectual freedom and our intellectual philosophy. We owe to them even the last abstractions of our physics, and more than all, that precious inheritance of ideal beauty in art which no purely Hebrew philosopher ever dreamed of. Dwelling, as we of this age mainly do upon the methods of God, the secondary divinities, as it were, of chemical and molecular force, we tend to lose our way; but the Hebrew, absorbed in the living and personal unity underlying all, does not recognize sufficiently the beauty and diversity of that outward nature which is well called the garment of the invisible God.

As might be expected, our author strenuously, and we believe, triumphantly maintains that the days of creation are not natural days, but periods of time. He shows that the notion of days of 24 hours is a comparatively recent one. This any one may verify for himself by reading the three last books of St. Augustine's Confessions. It is, moreover, clear from the narrative; for the natural day, depending upon the sun, could not have had any existence until the sun was created, upon the fourth day. Clearly, whatever Moses meant by "day," it could not be the usual period of 24 hours, but might well be a period of time occupied by the events which he groups together, and which we now know to have been of very great duration. The succession of creation is shown, in the fourth lecture, to be indicated in the Mosaic record according to the facts of Geology. One difficulty alone appears, which is recognized with great candour, on p. 105: it is that Moses records a great development of vegetable life in the same period when the dry land first appears, the third day, whereas no corresponding fossils have as yet been discovered in the rocks.

We have already seen that the old sceptical objection to the truth of Genesis, based on the formerly incredible statement of Moses that light was created long prior to the creation of the sun, has disappeared before the advancing science of our day. In reply to objections based upon the absence of fossil vegetation in the earliest rocks, it might fairly be urged that these primitive rocks, whenever yet seen, bear evidence of great alteration, which has re-arranged their constituents into crystalline forms. But Dr. Dawson points out that the discovery of Eozoon and the occurrence of graphite in these rocks, demonstrate the existence of organized life at that early period. This subject is ably treated by Sterry Hunt, in his address before the American Association, in 1871, and was more fully worked out in an address delivered in New York. He has for many years been maintaining that the enormous accumulations of iron oxides and metallic sulphides, and the great quantities of graphite which occur in the Laurentian rocks, can only be accounted for by supposing the existence, during that age, of a large development of organized life. To this conclusion, he states the views of Bischof also point, and in this direction the current of scientific opinion is now running. We may, therefore, confidently wait, in the belief that before long the following out of the line of research will justify in the fullest manner the Mosaic narrative. As it exists, it must be admitted that there is a difficulty, but it is much less formidable than it was a few years ago.

On page 24, the lecturer abundantly refutes that ridiculous theory, inculcated so generally of late years, that Moses intended to convey by the word translated "firmament" in our version, the idea of a hard and solid arch, like a hammered metal plate, in which the sun, moon, stars and planets were firmly fixed, like lamps. This absurd notion seems to have been suggested by a misconception of the true force of the Latin word "*firmamentum*," which our translators found in the old Vulgate version. They retained the English derivative, which certainly never had any meaning of dense solidity in its customary usage, and in the margin they put the word "*expansion*," as being the nearest equivalent to the Hebrew, and although not in common use, like the word *firmament*, yet important to be borne in mind in a close examination of the passage. This may be seen in any marginal Bible; and yet, with the most audacious unfairness, the impugners of Genesis seek to fasten the "hammered plate"

theory on Moses—a theory which they they themselves evolved out of their own consciousness, and which never was held by Greek, Roman, Chaldean or Egyptian, but was invented in modern times and foisted on Moses to bring the Bible into contempt. No other book is treated so unfairly as the Bible. Our English word "heaven" is derived from an Anglo-Saxon word, "hefan," to heave up, and we every day speak of the "vault," or the "arch," of heaven. Shakspere constantly speaks of the "floor" of heaven. Could any one suppose that any idea of solidity is conveyed by the use of this class of words? Dr. Dawson gives a very apposite quotation from Milton, precisely defining our English usage.

> "The firmament, expanse of liquid pure
> Transparent, elemental air diffused
> In circuit to the uttermost convex,"

and shows, by references to Job xxxvi and Ps. civ, that the idea expressed by the Hebrew word was one simply of spreading or expansion. The verb correlative to the noun "*rakia*" expresses an idea of tenuity utterly opposed to solidity. It means to stamp or beat out thin, as when gold is beaten out thin for gilding, or, in another passage, when the enemies of God are said to be scattered or trodden out, as it were, thin under foot, so as to offer no further resistance. We repeat that the idea is one solely of expansion and tenuity.

The origin of the adoption of the word "firmament" must be sought in the Septuagint translation, where *rakia* is translated "*stereoma*," and the enquiry naturally arises why that word was selected in this particular passage; for it has been too hastily assumed that "stereoma" and "firmamentum" can have no meaning but that of a solid arch whatever may be asserted concerning the Hebrew "rakia." The Septuagint translation was made at a time when Greek science had reached its most brilliant period—at the court of the most cultivated of ancient princes, and at Alexandria, the resort of all the scientific men of the age. The advancement of astronomical science at that day is often greatly under-estimated. The relative distances of the planets and their movements were well known and calculated with precision. The heavens were all mapped out, and the seasons, cycles, eclipses and other leading facts in astronomy were thoroughly familiar to all in the year 277 B. C. What specially impressed the mind of the ancient astronomer was the

certainty of these motions and the stability and unchangeableness of the orbits of the heavenly bodies. These were held in their unerring rounds in a way mysterious to them, each in its own zone, beyond which it could not vary. The nature of the supporting power was guessed at in the books passing under the name of Hermes Trismegistus, where the stars are represented as moving in a stable extension of space, in spheres of motion fixed by the opposition of two forces. These books of Hermes are the product of Alexandrian philosophy, and contain many such intimations that our discoveries of modern times were more than guessed at by the philosophy of old days. These fixed zones of motion are clearly indicated in the dream of Scipio, at the end of Cicero's treatise on the commonwealth, and more clearly in the commentary of Macrobius upon this dream, four centuries later. No notion of solidity or hardness was entertained. Scipio passes through the clouds and the air, from sphere to sphere, and looks down upon the earth from the most distant. The idea of law is always present, and the Greek word *stereoma* simply expresses this idea of fixity and stability in the heavens, and is the Greek scientific gloss upon the Hebrew word expansion.

The word *stereoma* occurs but once in the New Testament, at Col. ii, 5, where it means steadfastness or firmness of mind. It is used elsewhere to express that which makes strong or firm. So Aristotle calls the skeleton the *stereoma* of the body, and Theophrastus uses the same word for the keel of a ship, which supports the timbers. It also means that which has been made firm or solid, and hence also its secondary meaning of a solid cubic body. This last cannot be the meaning here, for in this "stereoma" the birds are represented as flying, and the planets as moving. To suppose that a solid body, dense, according to the usual idea of a cube, stretching from the sea beyond the stars, as being indicated by the word, is a manifest absurdity. Moreover, the word *stereoma* is a verbal noun, and the verb is derived from a root signifying to place or stand—hence the verb itself always signifies to confirm, establish, or settle, not to make physically solid. It is so used in Isaiah xlii, 5, where God is said to establish the earth and all things which are therein.

The Latin word *firmamentum*, the equivalent of *stereoma*, is always used in the sense of a stay or support, to make strong. So Cæsar uses it for a cross stay of wood to tie together two props supporting a leaning wall. Livy uses it of a detachment

taken from the reserve to the forefront of a battle, as a support to the troops engaged. Cicero repeatedly speaks of an important witness as a *firmamentum* in a trial, and of an argument as a *firmamentum* in an address. The notion of cubical solidity never belongs to this Latin word. Like all words with a similar termination. it carries out the root meaning of its verb, which signifies to make strong.

While Moses then was dwelling upon the fact of the expansion of the heavens, his translators added also the idea of strength, to bear up those heavenly bodies which they conceived as floating in them. This idea of strength is abundantly indicated in other passages of the Hebrew by other words, but not in this passage, where the physical appearance of the expanse only is denoted. Of all the contemptible theories which have been excogitated by the ingenuity of those who sit in the seat of the scornful, this "hammered plate" theory is the most preposterous.

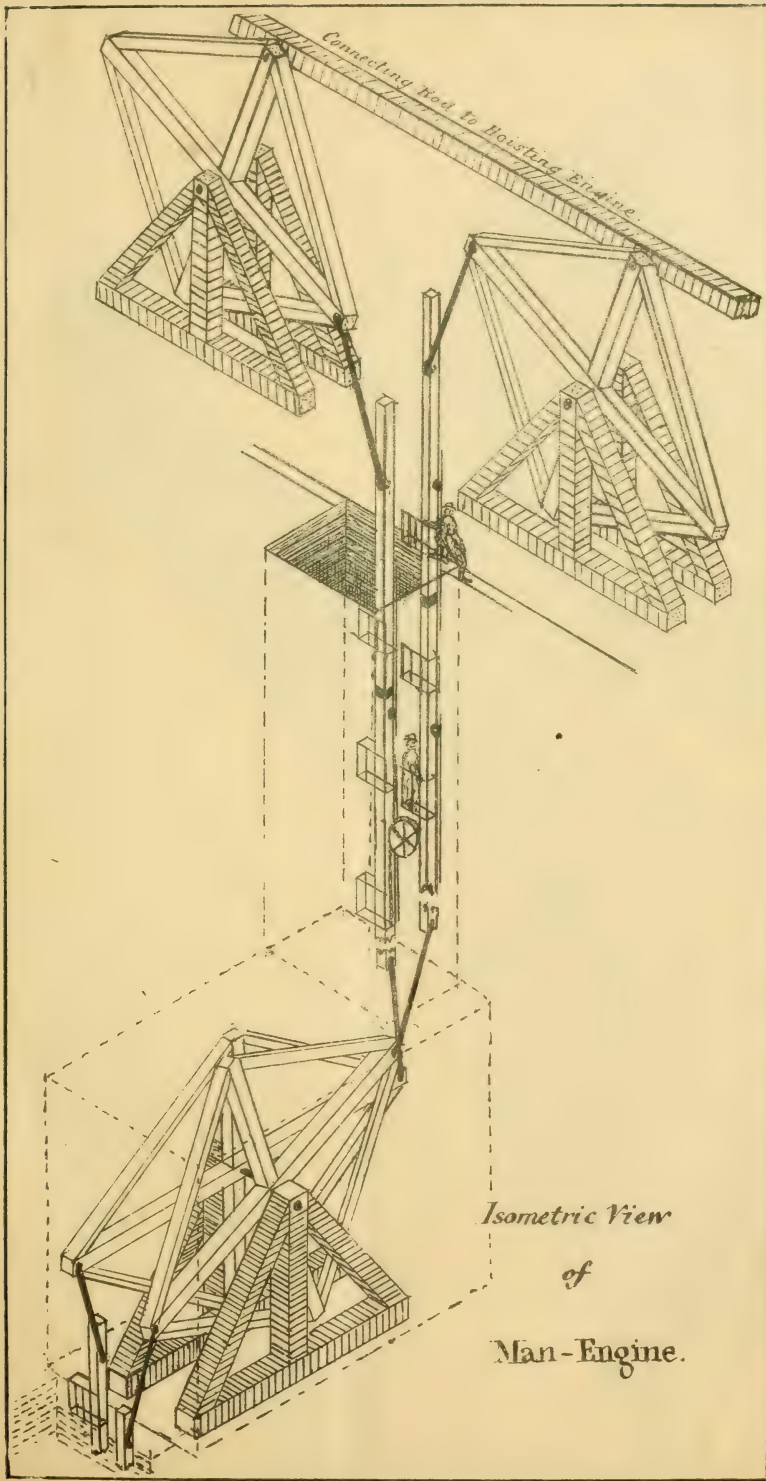
Upon the question of miracles, Dr. Dawson takes the ground that they are not suspensions of law. And this ground is a perfectly tenable one upon its theological side; for it be once admitted that there is an intelligent and powerful Will existent in the Universe, we can easily understand that any wonderful and unusual work can no more be considered as a suspension of law than our own acts of volition, exercised physically, as, for instance, when we arrest the motion of falling bodies, can be considered as suspensions of the law of gravitation. The ultimate cause, in both instances, is a moral cause, that of *will:* the one of a limited human will, and the other of a Divine, All-powerful Will, containing the ultimate forces of the Universe.

We have space only to advert to the notices of the theories of Huxley and Tyndall regarding the non-existence of vital force. These eminent philosophers are endowed with such a power of vivid expression, and such force of imagination, in addition to their great scientific powers, that it is not surprising if they are sometimes carried away by their own picturesque methods of grouping facts. Sometimes the unscientific mind is led astray by them; and we can never get over a slight feeling of resentment towards Huxley when, after falling down and worshipping his new deity Protoplasm for the space of a month or two, we suddenly discovered that it was nothing but an old familiar friend, albumen in a new Greek dress. Ever since that time, we have been shy of these brilliant paradoxical phrases. Some

instances are given, in these lectures, of those verbal *tours de force.*

We must now take leave of Dr. Dawson's lectures. They are valuable contributions towards a harmony of the conflicting claims of Science and Religion, and very suggestive and provocative of thought. We sincerely hope they will have an extensive sale, for we are sure that they will tend to create a fairer mode of treating the Bible than either savans or theologians usually employ. What with the savans taking metaphors literally, and the theologians taking objective statements metaphorically there never was a book so unfairly treated.

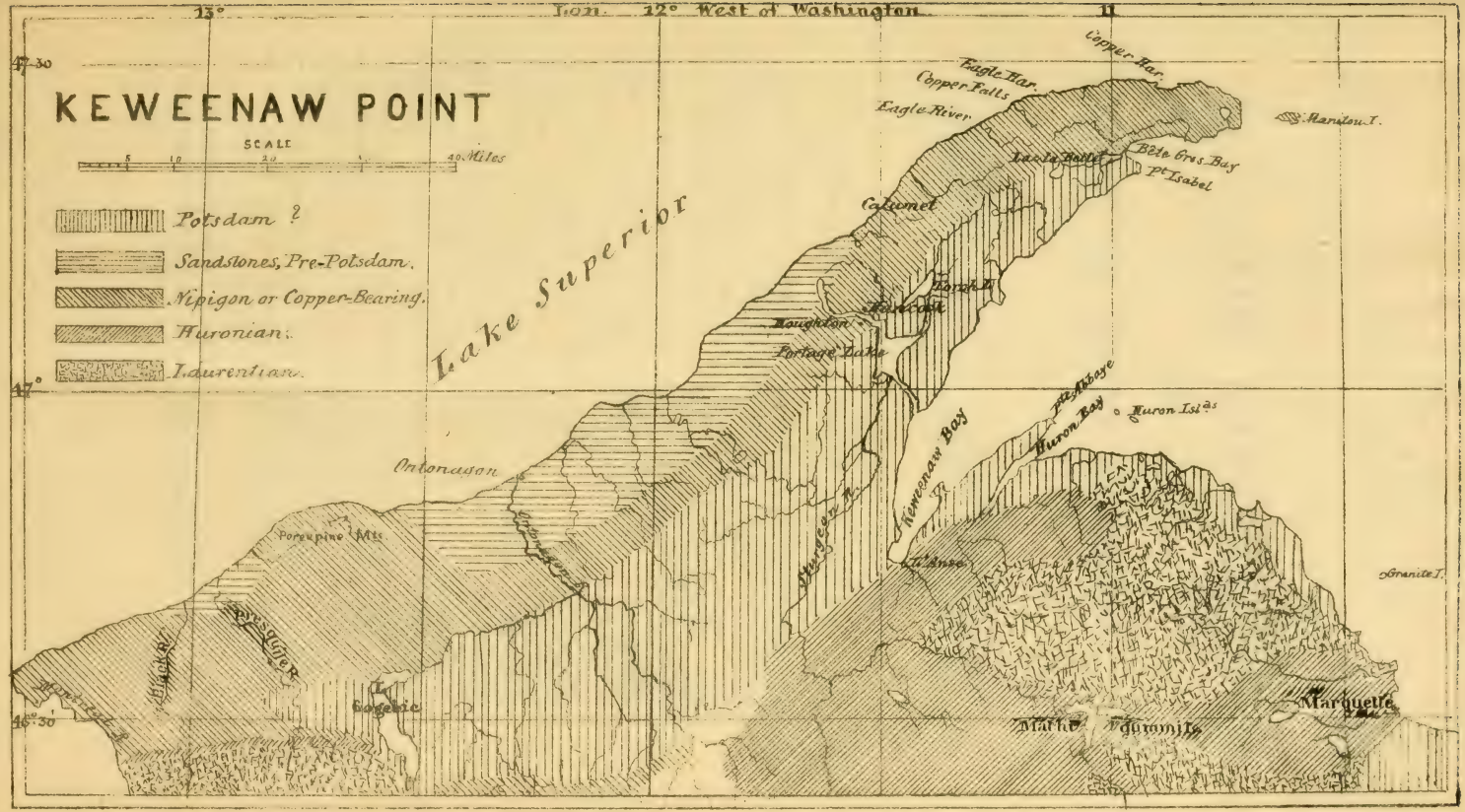
S. E. D.



Isometric View

of

Man-Engine.


KEWEENAW POINT
SCALE
40 Miles
Potsdam ?
Sandstones, Pre-Potsdam.
Nipigon or Copper-Bearing.
Huronian.
Laurentian.
Lon. 12° West of Washington
Lake Superior
Copper Har.
Eagle Har.
Copper Falls
Eagle River
Manitou I.
Lac la Belle
Belle Grès Bay
Pt Isabel
Calumet
Lac la Belle
Houghton
Portage Lake
Keweenaw Bay
Huron Bay
Huron Islds
Ontonagon
Porcupine Mts
Presque Isle R.
Black R.
Montreal R.
Bergelie
Sturgeon R.
Granite I.
Marquette
Marble Mountain

THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

ON THE NIPIGON OR COPPER-BEARING ROCKS OF LAKE SUPERIOR, WITH NOTES ON COPPER MINING IN THAT REGION.*

By Joseph William Spencer, B. A. Sc., Min., Eng.

I.—Prehistoric Mining and Early History.

The existence of copper on the shores of Lake Superior has long been known. Before the historic period of America, many localities had been wrought to obtain this useful metal, which was prized more highly than gold by the Aborigines who used it for ornaments rather than for useful implements. These earliest miners are supposed to have belonged to the age of the Mound Builders further south. They are known by the remains of their mining operations alone. They appear to have visited Lake Superior only in summer, as no traces of winter habitations, burial places, or other evidences of winter occupancy have been left. The most recent date assigned to their visits is variously estimated, from the growth of trees over their waste heaps of rocks, at a period of 300–600 years ago. Of all the copper mines that have been opened and worked in modern times in this region, it is said that none have been discovered which have not borne evidences of former operations. These ancient workings generally consist of pits, excavated sometimes to a depth of fifty feet or more. In some instances, horizontal galleries have

* Illustrated with specimens, and read before the monthly meeting of the Montreal Natural History Society, February, 1876.

been drifted for 30 or 40 feet, and to these there have sometimes been sunk second pits or winzes for ventilation purposes. The piercing or drifting into the rocks was accomplished by heating them to a high temperature with large fires, and then suddenly cooling the rock with water, thereby causing them to crack. The greater advancement in the mining art is displayed in the Evergreen Range, in Ontonagon County, while farther north and on Isle Royale their skill appears to have been somewhat more primitive. In some instances, the aboriginal miners have left large blocks of copper at the bottom of their pits, as unmanageable. In the old Minnesota Mine, one of these masses, weighing seven and a half tons was found at the bottom of their workings, raised on skids, with the branches battered off. Numerous stone-hammers, wooden-shovels, wooden-bars, pieces of hides, bark vessels, a few copper implements, and other rude appliances have been found in their workings. The most common of these are the hammers, which are oval boulders of *diorite* or *granite* having sometimes one groove, or even two grooves around the centre, to prevent the straps that fasten the stone to the handle from slipping. The hammers weigh from two or three to more than fifty pounds. All the copper implements that have been found were beaten into their present forms and were not made by casting the molten metal.

After the *Stone-hammer People* left this region to return no more, the shores of Lake Superior seem to have become untenanted for a time by man; but when the early Jesuit missionaries visited the lake 250 years ago, they found the south shore thinly peopled by Chippewa Indians. The old men at this time stated that that tribe had recently migrated, and having been driven westward, settled about Lake Superior, as this region was unoccupied.

La Garde appears to have been the first of the Jesuits who mentioned the existence of copper about Lake Superior, its occurrence he recorded in a work published in Paris in 1636. Thirty years later Claude Allouez noticed the native copper which, in small masses, the Indians regarded as gods. Again, in 1721, De Charlevoix described some of the copper deposits, and the superstitious reverence paid to the metal by the natives. Owing to the representations of Captain Jonathan Carver, who had visited Lake Superior in 1765, an English Mining Company was formed, which commenced operations in 1771 on the Ontonagon River; but these were abandoned the following year.

Between 1819 and 1841, several American exploring expeditions were sent out by the government; but the first of these that could be considered scientific was begun in 1831 by Dr. Houghton, State Geologist of Michigan. His report in 1841 drew the attention of capitalists to this region, and it was not long before the development of the mineral wealth about Lake Superior was begun.

II.—Geology.

This paper is largely the result of personal observations during parts of the last two years, while engaged in geological and mining operations among the copper mines on Keweenaw Point and elsewhere. I have consulted the reports of the Canadian and Michigan Geological Surveys, and I also acknowledge indebtedness to L. G. Emerson, M.E., for having pointed out many geological phenomena,—the knowledge of which would otherwise only have been gained by much longer study of the region. In this paper, too short for more than a general idea, I have endeavoured to point out the most striking scientific features, and to correlate the knowledge of the Copper-Bearing Series, as it has been obtained on both the north and south shores of Lake Superior.

*a.—Geological Distribution.**—The deposits of the geological formation known as the Nipigon or Copper-Bearing (formerly Upper Copper-Bearing) Series is peculiar to Lake Superior. On the south shore of the lake, they skirt it from the extremity of Keweenaw (more correctly Kewaunona) Point in the Upper Michigan, south-westwardly for 150 miles into Wisconsin. The exposed breadth varies from 4 to 15 miles. This region is considered the type of the formation, as it is best known. Topographically it consists (in part) of two ranges of hills known locally as the Greenstone or North, and the South Ranges. The North or true Mineral Range rises to heights of 400–700 feet, and slopes gradually to the north-westward, till it underlies the lake or (in places) a more recent formation. In the upper part of Keweenaw Peninsula, this has a breadth of about two miles. The south-east side of this range terminates in an abrupt declivity, the face of which consists sometimes of an almost vertical wall 200–300 feet high. The South Range varies in height

* See Map.

from 600 to 800 feet above the lake, and is more generally covered with iceberg drift deposits. The intervening valley with various rivulets is often very picturesque, having on one side the bolder hills pierced with deep gorges, while on the other there is the moulded contour of the higher southern range. In many places the hills enclose pretty lakelets, while an occasional peak towers to a considerable height above the range. Here and there, throughout the "Happy Valley," active mining villages, and the remains of those long since deserted, are to be seen side by side.

The Copper Bearing Series forms a broad belt to the west of Lake Superior extending from Fond du Lac to Thunder Bay. A large portion of Isle Royale is made up of the rocks of this formation.

According to Professor Robert Bell, of the Canadian Geological Survey, the Copper-Bearing Series of rocks on the North Shore is most largely developed in Nipigon Basin, including Black Sturgeon River, and the shores of Nipigon, Black and Thunder Bays. The deposits in this region extend for 170 miles northward from Lake Superior, and the greatest breadth is about 80 miles. Lake Nipigon is situated in the eastern portion of this basin. Owing to this wide distribution Professor Bell has proposed the name Nipigon Series for this peculiar geological formation, it being more suitable than the old provisional name of Upper Copper Bearing Series. These rocks are described by Sir William Logan, and Mr. Macfarlane, and more fully in the recent reports of Professor Bell to Mr. Selwyn, the Director of the Canadian Geological Survey.

The same rocks occur in patches eastward of Nipigon Bay, and also on Michipicoten and other islands. It is probable that when this wide-spread region is better known, many localities will be found to be of as much economic value as those rich mineral deposits on the south shore of the Lake.

b.—*Lithological Structure.*—Lithologically the copper-bearing series of rocks is peculiar, and consists of alternate beds of igneous and sedimentary deposits, the former predominating. *Diorites, melaphyres* (altered trappean rocks) and *amygdaloids* form the group of igneous rocks, and *sandstones, conglomerates,* and some *argillaceous seams* make up the group of sedimentary origin.

The *diorites* are composed of *hornblende* and *labradorite* or else *oligoclase*. The texture varies from that of fine grained *aphanite* to coarsely crystalline and in some the structure is porphyritic, large crystals of triclinic feldspars being present. When exposed the rocks weather so as to leave knobs of lustrous hornblende. In some places the tendency is to a columnar structure.

The larger portion of the formation consists of trappean rocks, called *melaphyres*, and true *amygdaloids*, the one graduating into the other. The term *melaphyre*, was used by Dr. Hunt, and applied by the Geological Surveys of Canada and Michigan to the numerous trap-like rocks, having the pyroxene or hornblende matter replaced by a ferruginous chloritic substance, besides some other compound silicates. The texture of these rocks varies from a fine grained and compact to coarse and sub-crystalline condition passing through every step. The *melaphyres* generally graduate into the overlying *amygdaloids*, but sometimes the lines of demarcation between the different beds are quite distinct. The color of the rocks is different shades of green, or else brownish or reddish. The rocks are tough owing to the undecomposed feldspar, yet they are easily scratched as the hornblende has been replaced by soft chloritic earth.

The *amygdaloids* are only *melaphyres* in which the alteration has gone further, and having the cavities filled with the products of the decomposition of the original rocks, or else with other substances introduced by infiltration. The amygdules vary in size, and commonly consist of ferruginous *chlorite*,—called *delessite*,—above referred to as a component of the *melaphyres*. *Calcite*, *quartz* and various *hydrous silicates* are often largely deposited in the cavities. The color of the *amygdaloids* is generally some shade of green like that of the *melaphyres*; both rocks containing much iron, which is sometimes present as minute grains of *magnetite*.

According to Macfarlane the analysis of a coarse variety of melaphyre gave:

Delessite,	46.36	
Labradorite,	47.43	
Pyroxene or Hornblende	5.26	
Magnetite,	0.95	
		100.00

The composition of the delessite, he gives as follows:

Silica,	31.78	
Alumina,	15.47	
Ferrous Oxide,	28.87	
Lime,	9.64	
Magnesia,	4.37	
Water,	9.87	
		100.00

The amygdaloid consists of

Delessite,	38.00	
Labradorite,	62.00	
		100.00

Among the silicates occurring in the amygdaloids are *Epidote*, *Prehnite*, *Laumonite*, *Analcite*, *Datolite*, &c. Besides these, *Heulandite*, *Chabazite*, *Apophyllite*, *Stilbite*, *Natrolite*, *Leonhardite*, *Mesolite*, &c., are obtained from the fissure veins.

The *conglomerates* are principally composed of brown felsitic pebbles, often with small imbedded crystals of triclinic feldspars. Occasionally the pebbles are bright flesh red, derived from minute crystals of feldspar of that color. Sometimes the pebbles are of amygdaloidal trap. The matrix is generally dark brown having a texture from sub-crystalline to almost a compact vitreous mass. In some localities the pebbles contain no free silica, while in others the rocks are almost jaspery. The cement is fine grained, and is either siliceous, chloritic, epidotic, cupriferous particles, or else it consists of the comminuted material of the pebbles. As noticed by Pumpelly, the amygdaloidal conglomerates can often be traced over several miles, as the filling of different beds is sometimes uniform over a considerable distance. The felsitic and jaspery pebbles of certain conglomerates appear to have been derived from Huronian rocks, which were exposed somewhat beyond the limits of the igneous overflows during the period of time under consideration.

The *sandstones* are usually of a brick red color, although some of the beds are light yellowish. The sediments of which these rocks are made up has been principally derived from the material of the conglomerates. The beds have frequently a slaty character, the argillaceous material being derived from the decomposition of the feldspars. Some of the beds, as at Copper Falls, show their shallow water origin, as they have ripple and rain drop markings, and mud cracks. The limits of the sandstone strata are usually well defined, although some of the beds seem to be united with the overlying melaphyres, as if the porous sand

stone had been permeated by the liquid trap which has since been converted into the melaphyres.

On the north shore of the Lake the variety of the sedimentary rocks is somewhat greater. As shown by Bell, to the above list may be added dark massive argillites, and flaggy black shales, having the mass divided by numerous vertical joints, red shales, red and white dolomitic sandstones, reddish compact limestones, and red and yellowish-gray marls.

c.—*Geological Structure.*—The typical series of the copper-bearing rocks on the South Shore has a great development, having an average width of six miles. It is more than 150 miles long, and its thickness, as shown by the Geological Survey, is not less than 15,000 feet, or nearly three miles. The greatest thickness is to the northward. The range of hills, made up of the deposits of the Nipigon or Copper-bearing Period, has a trend of about N.E., while the dip is N.W., at angles varying from 60 to 25 degrees, flattening out to the north-eastward. The lapse of time occupied for the deposition of so much material must have been very great. During all this time there were long series of submarine volcanic eruptions, which, occasionally ceasing to act, permitted the abrading forces to be forming the pebbles which were deposited in the shallow seas to form what are now the intercalated beds of conglomerates and sandstones. A gradual subsidence was going on while the seas were getting filled with so much igneous and sedimentary matter. The deposition of the sandstones was comparatively rapid, and the time was insufficient for the bleaching of the red rocks by decomposing organic remains, if they were present. The whole series, made up of alternate layers of igneous and sedimentary rocks, has its respective beds conformable, although the individual members are not uniformly deposited. Thus the Allouez Conglomerate can be traced for thirty miles from Portage Lake north-eastward, having a thickness of 15-20 feet at the Allouez and Central Mines, a distance of 15 miles apart, while at the Phœnix Mine, between the two others, the stratum is represented by a thin clay seam, a few inches thick.

Again, the great *Diorite Bed*, which has a thickness of 1,200 feet at the Phœnix Mine, thins out at a distance of about twelve miles to the south westward of this mine, while it extends a long distance to the north-eastward. This large development of diorite consists of various beds having thicknesses varying from 10 to 400 feet, and characterized by rocks of various textures.

Thus we see that the gigantic forces at work, building up and carving out a monument of a long age, were not equally potent. The surfaces of the beds of sandstone in many places were sculptured before the succeeding deposits of igneous matter.

The relative position of the melaphyres and amygdaloids is nearly constant; the former compact rocks being at the base, pass gradually through the various stages till the upper beds become perfectly amygdaloidal. The different beds vary in thickness from a few feet to more than 150 feet, and have the lines of demarcation between them often quite distinct. The change from the compact traps to the amygdaloids is probably due to the structure of the deposits rather than to the greater and more recent internal changes, or metamorphoses, as the upper beds of the original trappean overflows would incline to a more vesicular structure than those subjected to a heavier pressure at a greater depth.

Along the lower waters of the Eagle River, a section of the Cupriferous series is exposed for a distance of more than two miles across the formation. It was measured by the Michigan Geological Survey, and more than 160 beds were plotted. This together with the section of Portage Lake region may be summed up as follows, in descending order, having a vertical thickness of:

Conglomerates and *sandstones* dipping under the lake, but of which there is an exposure of,	2,500 feet.
45 beds of *melaphyres*, *amygdaloids*, *conglomerates*, and *sandstones*—there being 10 beds of the sedimentary rocks with an aggregate thickness of 400 feet, reaching to the "Ash Bed,"	1,500 "
45 beds of *melaphyres*, and *amygdaloids* with some thin seams of *sandstone*,	1,400 "
18 beds of *diorites*, beneath which is the representative of the *Allouez Conglomerate*,	1,200 "
60 beds of *melaphyres* and *amygdaloids* reaching to the (recently discovered) supposed representative of the *Calumet Conglomerate*,	1,200 "
Melaphyres, *amygdaloids* and a number of beds of *conglomerates* and *sandstone*, extending from the *Calumet Conglomerate*, to the base of the series,	7,700 "
Total thickness of the Copper-Bearing Series on Keweenaw Point as far as known,	15,500 feet.

On the north shore of Lake Superior, the Nipigon or Copper-Bearing Series is represented by a similar intercalation of igneous and sedimentary rocks. These deposits are divided by the Canadian Geological Survey into two groups which are not conformable. The Lower Group, called by Hunt the Animikie, is somewhat different lithologically from the lower members of the series on the South Shore, as it is largely composed of conglomerates, cherty layers, some dolomites, and massive black shales with occasional beds of trap. In some of the beds carbonaceous matter has been found. The Upper Group contains some dolomites and limestones which are not present on Keweenaw Point. The Lower Group of the Canadian geologists occurs principally to the north-west of Lake Superior, while the Upper Division lies to the north and east of the lake. According to the measurements of Bell and Macfarlane, in different places, the Nipigon or Cupriferous Series, on the Canadian side of Lake Superior, attains a thickness of 13,000 to 16,000 feet, including upwards of 2,000 feet of conglomerates. In the Nipigon Basin this formation attains its greatest thickness about the middle and southern portions, while to the northward it thins out. The trend is northerly. The deposits are sometimes nearly horizontal, and seldom is the dip greater than 15-20 degrees, although in some places the strata are thrown up at high angles. Thunder Cape and very many of the hills on Nipigon, Black, and Thunder Bays, are capped by thick deposits of trappean rocks, which are deposited almost horizontally, resting unconformably on either the Lower or the Upper Group of the Copper-bearing or Nipigon Series. The wrinkled structure of the trap rocks indicates the different directions of the igneous overflows. The material of these eruptions, according to Bell, had a north-westerly direction on Thunder Bay, while on Isle St. Ignace they were to the north-eastward, and to the east of the lake Sir William Logan showed them to have had an easterly direction. Everywhere, on leaving the great lake basin, the Nipigon deposits thin out. Numerous trap dykes traverse this formation on the North Shore, but on the south side of the lake they do not appear to pass higher than the Huronian Series, while the veins are filled with metamorphosed aqueous infiltrations, or with the *débris* of the adjacent rocks.

Both on the north and south shores of Lake Superior, the beds of the Nipigon Formation are considerably faulted. Between the Phœnix and Central Mines on Keweenaw Point, there

is a horizontal dislocation of 400 feet, being equal to a down-throw of 200 feet. At Portage Lake the faulting amounts to over 700 feet horizontally. The effect of this fault has been to weaken the country, and since denuding agencies have made an excavation across Keweenaw Peninsula, having a depth of six or seven hundred feet through the Range. The lower portion of this valley is now occupied by Portage Lake.

Bell has suggested that the igneous eruptions occurred within the present basin of Lake Superior. This was probably the case, and what is now the bed of the lake was the scene of action for some gigantic submarine volcanoes, which piled up two and a half or three miles of solid rocks. The axis of the great eruptions appears to have been somewhere between Keweenaw Point and Nipigon Bay, where were the thickest deposits, whence the material flowed all around, having a radius of 150–200 miles. It is probable that the great basin of Lake Superior, which is one of aqueous denudation, is due to the great weakening of this region by the numerous dykes and faults belonging to the Cambrian or Pre-Cambrian Ages, arising from the many channels of eruptions during those Ages; for while the crystalline Laurentian, Huronian, and some of the Nipigon Series of rocks, have withstood so persistently the denuding agencies of countless Æons, we find in the centre of them, the largest or one of the largest lake basins on our globe; and that the former scene of the greatest disturbance is now covered by the deeper waters of the lake.

d.—*Geological Age of the Nipigon or Copper-Bearing Series.*—The Geological age of these rocks has long been an open question, as recourse to organic remains cannot be made. Nor is it probable that future researches will unveil many fossils, as the conditions of the seas were totally unfavourable to life. At each eruption all organisms would tend to be destroyed. The red sandstones also indicate, at least, a scarcity of vegetable existence, and then the time elapsing between each period, when the sedimentary deposits were forming, were occupied by long successions of volcanic eruptions. However, in one of the sandstone beds, near the top of the Cupriferous Series, over which the Eagle River flows, and near its mouth, a Mr. Uren found an obscure fossil, but as he stated to me, he cared not for palæontological remains and consequently gave it to another gentleman, who was not scientific. Dr. Sterry Hunt also mentioned the possi-

bility of the existence of some sponges in Michipicoten Island. I know of no other evidences of life during this period, unless the carbonaceous matter in the Lower Group of the Series on the North Shore points in this direction. Consequently it is stratigraphy and lithology that must disclose the venerable age of these interesting deposits.

Pumpelly has recently shown that the Cupriferous and Huronian Series appear to be conformable, both in dip and strike, for a distance of 30 miles from the Montreal River, on the borders of Wisconsin, to Lake Gogebic—dipping northward at angles of from 50 to 70 degrees. This is the only known exposure of their junction on the South Shore. On the North Shore, Bell has ascertained that the Nipigon Series is unconformable to the Huronian in some places, while in others it rests on the upturned edges of the Laurentian. Again the great horizontal trap overflows, which cap so many hills north of Lake Superior, are unconformable to the other beds of the series. These capping trap beds are not present on the South Shore.

The western side of the range, forming the backbone of Keweenaw Peninsula, is overlaid by sandstones similar to those of the Cupriferous Series and apparently conformable to it. Eastward of this range the shores of Lake Superior are skirted by a narrow belt of red sandstones and shales, dipping according to Pumpelly at angles varying from 5 to 15 degrees towards the lake basin. Over these red sandstones, the country east of the mineral ranges is covered with light colored sandstones, often friable, which are deposited horizontally, and are supposed to belong to the Potsdam Period. They contain no fossils themselves, but are overlaid by other rocks, containing a few organic remains, which have been referred to the Calciferous or Chazy Formation; and these are overlaid by the fossiliferous Trenton deposits. The sandstones, on the east side of Keweenaw Point, overlie the Huronian deposits, and in many places contain pebbles of that series. It is not known if the Cupriferous rocks any where intervene between the sandstones and the materials belonging to the Huronian Age; but the western border of the sandstones abut against the upturned edges of the copper-bearing range, which dip away from them at angles varying from 40° to 60°. By some it has been urged that the line of junction, between the igneous and sedimentary formations, represents the plane of a gigantic fault, in which case there has been a down-throw whose

vertical depth would equal three miles or more. Near Houghton, there are some isolated patches of sandstone, which overlie beds of melaphyre, and contain numerous pebbles both of melaphyre and of Cupriferous Conglomerate, consequently showing their subsequent origin. As pointed out by the Geological Survey, the Copper-Bearing Rocks were greatly sculptured before the deposition of the sandstones; as there are places where the old hills were denuded leaving cliffs 200 feet high, having formed the old shore line, along which the Potsdam (?) deposits were being made.

The lithological characters of the Cupriferous Rocks resemble those of the Permian and Triassic Periods. As shown by Delesse, Naumann, Macfarlane, Bell and others, no rocks of similar lithological structure occur in any other part of the known world belonging to an older period than the Carboniferous or the Permian Ages. Now, if the Huronian Formation had been thrown into its present position, or nearly so, before the deposition of the Cupriferous Series, and the horizontal sandstones east of the range did not bear evidences of a subsequent origin, (although only in a few small isolated patches are they known to overlie directly the Copper-Bearing Formation), then there would be no stratigraphical grounds whatever for the determination of the age of the rocks under consideration, and we could only look to their lithological structure as a means of solving this interesting question. Again, Macfarlane points out the trachytic character of some of the rocks of this series which are situated on Michipicoten Islands, and this resemblance to modern volcanic products, which are not known to exist elsewhere in the Nipigon Series, might point to a comparatively recent date.

But the most recent investigations on the South Shore, made by Pumpelly and Brooks, go to show that the Huronian Series, in part, had not been uplifted to any extent before the deposition of the Nipigon or Copper-Bearing Rocks, as the two formations are conformable, and tilted together at high angles, while at no great distance from their junction, the Huronian is also contorted and overlaid by the horizontal Potsdam (?) sandstones. As we have seen the range was sculptured before the deposition of the sandstones, and the more recent origin of the latter rocks appears to be additionally confirmed by the isolated patches near Houghton containing Cupriferous pebbles.

If the ancient Mineral Range on Keweenaw Peninsula were not an old shore line (of which there are numerous indications),

but a gigantic fault, then we should expect to find the deposits of the Nipigon Period, between the Huronian and subsequent sedimentary rocks further east along the south shore of Lake Superior, but this is not the case. The trend of the rocks on Michipicoten Island is very nearly the same as that on Keweenaw Point, although they dip in the opposite direction. From this difference in direction of dip, and from the deep water between the Point and the Island, I would infer that the old Cupriferous Range was much weakened and broken between these two places, and subsequently was easily swept away by denuding agencies, leaving this deep portion of the Lake basin.

The south-eastern portion of the Lake Superior Basin does not appear to have been covered with the deposits of the Nipigon or Cupriferous Series but to have been excavated along the junction between the Nipigon Hills to the northward (which have nearly been swept away) and the softer sedimentary rocks to the south.

From the foregoing we see that part of the Huronian Series had not been upturned before the eruptions of the Nipigon or Cupriferous Age became general. It is probable that the dynamical agencies, which were exhausting themselves by covering up the Huronian sea bottoms to the south with igneous matter, were also at work upheaving the older rocks to the north—inferring that the eruptions began somewhat earlier to the southward of the series. This view is strengthened by the fact that the earlier beds of this formation on the North Shore are mostly made up of sedimentary deposits derived from the waste of the older crystalline rocks, with only an occasional trap overflow—the record of some extraordinary eruption.

The Huronian and Cupriferous Series were elevated together, having the greatest upheavals to the south, where the beds were lifted to angles of from 50 to 70 deg., while toward the north the inclination is comparatively low. Now this fact, with the absence of the great capping traps to the southward, together with their unconformability to the older beds of the Copper-Bearing Series to the north of Lake Superior, would tend to show that the seat of volcanic eruptions moved northward, and ended there later than to the south, while the upheaving forces were acting in the opposite direction. The last upheaval to which the south shore of Lake Superior was subjected, probably occurred shortly previous to the deposition of the Potsdam sandstones.

From all the foregoing we conclude that the Nipigon or Copper-Bearing Series belongs to a period newer than the Huronian, and although the first to follow, it is not a continuation thereof. The evidences point to its being older than the Potsdam, and consequently the deposits appear to have been made in the Lower Cambrian Age of Europe, and probably the Nipigon Formation is nearly, in point of time, the American representative of the Longmynd of Wales.

c.—*Occurrence of Copper.*—Unlike other copper-bearing regions, this formation holds its deposits in the metallic state. Although the metal seems to be scattered through the whole formation in minute quantities, yet for mining purposes it occurs only in certain beds and veins where a long process of concentration has been going on, and perhaps is still in progress. The beds in which copper is deposited in workable quantities are those of amygdaloid and conglomerates through which the metal is distributed in minute grains and small masses. Paying quantities are usually confined to the upper five or ten feet of the beds, and the proportion of the metal is more or less constant, although it apparently traverses them in zones.

The greater porosity of the upper portions of the trappean rocks afforded more favorable conditions for the decomposition of the pyroxene or hornblende, and the subsequent formation of the ferruginous chlorites, and admission of other substances, as well as the copper concentrated by means of aqueous infiltrations and subsequent deposition by chemical or electro-chemical processes. As a proof of electrical action, I refer to some recent experiments for the Telegraph Company, by which it was found that there were frequent electrical currents traversing the Mineral Range, which often altered their courses, to the annoyance of the operators, until the source of trouble was discovered.

To the south of Lake Superior numerous veins traverse the Copper-Bearing Series. These Marvine divides into three groups; the two principal systems being more or less transverse to the beds: "the one trends from N. 15° W. to N. 25° W., with nearly vertical dips, but to the westward; the other, N. 16° E. dipping nearly vertical, but to the eastward; and the third trending with the formation, but with a steeper dip." The first system is faulted considerably, while the two other systems are scarcely known to be. The veins are filled with infiltrated matter principally, although masses and fragments of the adjacent beds

are enclosed. Much of the vein fillings is *green earth*, *calcite*, often much *laumonite*, *datolite*, &c. In these the copper usually occurs both distributed in small grains, and in masses sometimes weighing many tons. One solid mass of copper was obtained in the old Minnesota Mine, which weighed about 450 tons, being 47 feet long, 18 broad, and 9½ in thickness, requiring 14 months in order that it could be cut into portable pieces. This formerly profitable mine is in a vein belonging to the third system, but the more successful mines are in the veins belonging to the first system. Often between the large masses there is much poor rock, and although often richer than the beds, the percentage in long workings is less, as the deposits are more uncertain.

Though many beds and veins are known to contain copper, it is generally limited to certain portions, where valuable deposits are found, and veins often side by side, or in continuation, and of the same age, are found not to be of equal value. Mines averaging only one and a half per cent. of copper of all the rock taken out can be made to pay well; even from the celebrated Calumet and Hecla mines, the ingots of copper only amount to one twenty-fifth of the rock treated. As the profitable mines are scattered so widely, and also the great veins and cupriferous beds occurring on Keweenaw Peninsula, it is doubtless that time will reveal an inexhaustible supply of the metal. When a large amount of capital will have been expended in researches on the Canadian side, probably no inferior results will be obtained, but at the present little more than the wide existence of cupriferous rocks is known.

However, the structure on the Canadian side of the Lake is not quite like that on the south side, and as remarked by Bell, the metalliferous beds are confined mostly to the Upper Groups of the Series. Throughout the amygdaloids on the Canadian side of the lake there are intrusive masses of traps in the Upper Group. The dykes are of *greenstone*, *porphyry* or *syenite*, and these often stand in relief, being weathered with more difficulty than the country rocks. Numerous fissure veins also occur of more recent origin than the dykes. Of both, there are two systems, the one coinciding with the range of the rocks, while the other set is at right angles to the first; and the series of cracks seems to be constant even throughout considerable areas. The transverse veins, on Thunder Bay, are north-west and south-eastward. As on the South Shore, the Upper Group has many amygdaloidal veins with fragments of the country rock and dark green

chloritic matter, sometimes slickensided — a structure common in Keweenaw. The veinstones are often quartz or calcite, or sometimes barite or fluorite. Laumonite in many places is most abundant, as it is on the South Shore. Sulphides, which seem to be almost absent in Keweenaw, are quite common on the Canadian side; as sulphides of copper, silver, iron, zinc, and lead, besides nickel, cobalt, molybdenum, uranium and arsenic.

Many other minerals occur on both sides of the lake, especially in the veins traversing the region under consideration. Besides the native copper on both sides of the lake, *malachite*, *chrysocolla*, *melaconite* and *cuprite* are found. Some years since a large pocket of *melaconite* was found at Copper Harbour, but the workings were abandoned. The *cuprite* or red oxide of copper usually occurs in small quantities in the sandstones and conglomerates, and I believe one or two beds of this ore have been found which contain as much as four per cent. of copper. *Whitneyite*, *Domeykite*, besides the various *hydrous silicates* mentioned before, as well as the sulphides just referred to, have also been found; silver, gold, and lead in vein formations have attracted considerable attention. Native silver occurs associated with the metallic copper, being deposited in a pure state on the latter metal. The two metals are not alloyed, and their contact surfaces are perfectly distinct; the silver, usually in arborescent forms, projects from the copper.

Recently, there has been considerable excitement over some silver-bearing veins which are situated in the Copper-Bearing Formation in Ontonagon County. The prospects of these are said to be encouraging.

The temperature of the rocks in which the copper mines are situated is low, and at a depth of 1,440 feet, it is scarcely higher than at the surface. Mr. Emerson made some experiments on this subject, by taking the temperature of the water which percolates through the rocks, entering the mines at different levels. He found that the average temperature at different places was not far from 60° Fahr. The cause of this low temperature may be attributed to the fact that the region of Lake Superior, which was so long subjected to igneous influences, and to great contortions of the earth's crust, has had very long ages during which it has parted with its heat, and this has not been raised in recent geological times by the bending of the various strata.

III.—Notes on Copper Mining in the Lake Superior Region.

Under this head it is proposed to notice briefly the art of mining as it has been applied to the Native Copper Mines of Keweenaw Peninsula, and to give a short sketch of the financial condition of the industry.

Ordinary blasting powder is almost entirely used. Nitroglycerine and dualin have been introduced, but several accidents having occurred, their use has been abandoned. One of the most fatal of these accidents was at the Phœnix Mine, resulting in the death of two mining captains and four other men. This explosion took place in the office of the captains, while some men were mixing the dualin with ordinary blasting powder, as the mixture was usually fired with fusees and not by electricity. There was a quantity of dualin cartridges in the building when the accident happened, and although the concussion was so great as to throw them several hundred feet, to the top of a high cliff, many were afterwards picked up unexploded. In some places, dualin was found unsuitable for blasting, as the action was such as to bring down too much waste rock in certain directions, but elsewhere it has rendered good service.

As noticed before, the copper is obtained from beds and veins. The beds which are worked dip at various angles from 26° (at the Copper Falls Mine) to 56° (at the Quincy), while the dip of the veins is usually greater than 73°. In almost all cases the shafts follow the inclinations of the beds or veins, changing with their variations of dip; and in only a few instances are the shafts perpendicular or straight throughout their whole depth. Some shafts have been sunk without any engineering skill whatever, and after thousands of dollars have been wasted, have been abandoned, and others sunk at great expense, this being more economical than to straighten those that were so crooked. The best work of engineering skill about Lake Superior is at the Phœnix Mine, where an additional shaft was required. The workings are on the side of a hill capped with a great thickness of greenstone, and it was found that it would be less expensive to sink a shaft at a low inclination, beneath the great bed of diorite, than to sink one perpendicularly through it. The mine

is on a fissure vein having a hade varying from perpendicular to 17°, and down which an old inclined shaft had been sunk for 500 or 600 feet, so crookedly as to become useless. Under the charge of Mr. L. G. Emerson, M. E., a new shaft was begun in the hanging wall at such an angle with the direction of the vein that it would be only a few feet from each level, with which it was afterwards connected—the vein-stuff and walls disintegrating very rapidly on exposure to air and moisture. This was sunk with a dip of 35° 55′ to a depth of 1300 feet (still being sunk), having a width of 8 and a length of 14 feet, costing without machinery, $76,000. The work was accomplished in 18 months, as several parties of men were being employed on different sections. The result was a perfectly straight shaft, now used for hoisting on one side, while on the other there is a stairway. The required timbering is very heavy in parts of its course.

The sections of the shafts are usually from 7 by 12 feet to 8 by 14 feet, and divided in two parts, one for hoisting and the other for ladderways or pumps, excepting in those where *man-engines* are constructed. All the large mines have two or more shafts, but some have as many as nine or twelve, besides adits where practicable. The galleries or levels are usually 10 sometimes 15 fathoms apart (vertically), connected by occasional winzes for ventilation, and for other purposes while the mines are being opened, and are usually about 7 feet high and 5 feet wide, being traversed by iron tram-ways, leading to the shafts.

The mining is almost always by overhand stoping, and in some cases the old stopes are completely filled with the broken waste rock.

All the material from one level to the next is removed, excepting what may be required for pillars, or may be too poor to be taken out, as the metal occurs in zones, often enclosing large areas of rock which would be unremunerative ; and some times even when two or three consecutive galleries have been driven for a long distance, the poverty of the rock compels large portions of the mines to be abandoned.

In most cases the drilling is done by hand—one man striking and another turning the drill, or else two men striking alternately where the rock is hard. However, in several mines machine drills are used, especially in stoping—the motive power being compressed air carried down by pipes from the surface, and

having a pressure of 60 pounds per square inch. Recently diamond drills have been introduced into the copper mines on Lake Superior for exploration purposes; one being used in the Quincy Mine at a depth of 1600 feet for sectional examinations, in place of the expensive cross-cutting. When we consider that none of the native copper mines (except the Calumet and Hecla) yield an average of two per cent of metal for all the rock broken, and also the great expense entailed in sinking and drifting through much poor rock, the only way to keep the mines successfully in operation is to open up two or three year's galleries ahead of the work, in order that when one remunerative area is exhausted, another may at once be ready for stoping, and thus a very considerable item in the annual expense of mining is expended without any immediate returns.

Sometimes the hanging walls are so strong that only pillars, at considerable distances apart, are required to support the roofs. But in 1872, a sad accident occurred on the *Ash-Bed* at Copper Falls. The pillars which had been left in part of the mine were insufficient, and a portion of the roof having an area of 200 by 300 feet fell, killing six or seven men, and entrapping others for several hours till released. However, this catastrophy could scarcely have been unexpected, for the pillars had been slowly but surely crushing and scaling off for more than a year, besides giving more recent indications. Seldom do large masses fall without giving warning, but the lives so exposed to danger come to be held cheaply, and work is often pursued in spite of everything, till either an accident happens, or at last prudence compels the dangerous parts to be abandoned, or the miners to be protected as much as possible. For this purpose I have known the openings to be completely filled with crib-work of timbers, at a very considerable expense.

The workings of the veins and beds seldom exceed a width or height of from six to ten feet, although the seams sometimes widen to twenty feet or more. The wider veins are often poor in copper, while in the beds, the metal is usually confined to the upper portion of the amygdaloids or conglomerates. The veins have generally well marked walls, sometimes slickensided, while the metallic portions of the beds do not usually have their limits well defined, or at least their foot-walls, and the metallic zones sometimes leave their primary direction and wander off into the lower parts of the beds.

The timber required is sometimes gigantic, and many of the *stulls* (or posts) have a diameter of more than three feet, and a length of 20 to 40 feet in places. In some of the mines the rocks, although hard and tough in mining, disintegrate very quickly on exposure to air and moisture, and temporary timbering is required to protect the men while they are placing the permanent timber and lagging. Such is the Phœnix Mine, which in some places does not require any blasting, for when water is thrown on the face of work, the rock slowly begins to crack and scale off. In such cases when stoping is begun in any place along a gallery, the work is pushed on as rapidly as possible without pausing (except during Sundays which are not observed in the Rocky Mountain mining regions), the slopes being filled in as the workings ascend, leaving only *mills*, down which to throw the copper rock to the gallery below, whence it is conveyed to the shafts. But in many of the mines, or in portions of them, the galleries and shafts require little or no timber. Skips are now almost invariably used for hoisting, although a few kibbles may still be seen. Down the shafts inclined railways are constructed with T rails, which weigh from 12 to 18 pounds per yard, and having gauges varying in different mines from 4 to $4\frac{1}{2}$ feet wide. The skips are made of heavy boiler plate, each weighing from one and a half to two tons, and having a capacity for two tons of rock. Some skips empty from the bottom, but usually their loads are dumped from the top, and in order to be self-acting, the back wheels are very broad (8 inches), so that when the conveyance arrives at the surface, (the rope being secured by a long iron handle, fastened at each side of the car near the horizontal axis of gravity) the fore wheels pass into a groove or break in the track, while, on the broad back wheels, the bottom of the car continues to ascend on the tramway, and thus upsetting, the skip dumps its contents into a car just below, ready to receive and convey them to the rock-house. The rock from the locality of work on each level in the mine is conveyed in other cars to the skips into which it is dumped. Wire ropes are almost entirely used, although hemp ropes are still to be seen. The sizes of the wire ropes employed are from one to one and a half inches in diameter, for the average load of four tons, the larger size being used in the deeper mines, some of which, down the inclines, are 1500-1800 feet deep. The foot walls are boarded and furnished with rollers, on which are carried the ropes, which, when properly

cared for, can safely be expected to last 18 months. In one shaft that I know, the ropes had been used as long as possible, and broke twice each of them after a use of 29 months. At Portage Lake, from the Quincy Rock-House to the Stamp Mill, there is a descent of nearly 500 feet in a distance of half a mile, the steepest grade having an inclination of 14° ; two full cars having a weight of 8 tons are run down an inclined tramway by gravity, and bring up two empty cars of half that weight, these trains of cars being connected by wire ropes over a drum at the summit of the hill. The rope, which is one inch in diameter, has been subject to constant use for 12 years, and although it has broken once (from accident) it is not yet worn out. The ropes which are not galvanized are always kept well tarred to prevent them from rusting. The transportation between the shaft, rock-houses, and stamp mills is also by various other contrivances than the one just mentioned. Sometimes when the railroads are not too long and nearly horizontal, the cars are attached to stationary engines by endless ropes, or again they are sometimes drawn by locomotives, by horses, or, where the distance is short, man-power is used. The car attached to endless ropes is so arranged that it dumps its contents,—this being accomplished by means of two small wheels near the back part of the box of the car, which project, so that when it passes a station near its destination, it runs up an inclined plane lifting the back end and causing the front to open.

The transportation of men in the mines is a subject of interest. Ladders are usually placed in each shaft. A stairway is used in the incline shaft of the Phœnix Mine, while in another shaft of low inclination at the Central Mine, the miners are transported by a car capable of carrying 25 men. At this mine, some years ago, 13 men were riding up in a skip, when the rope broke, and the accident resulted in the death of 10 men, the other three escaping, as the skip was thrown from the track and jammed, instead of going all the way to the bottom of the shaft. The officers are very strict in order to prevent the men from risking their lives by riding in the skips. In some of the deeper mines, as the Quincy, Pewabic, Cliff, Calumet and Hecla, *man-engines* have been constructed at very great cost. The longest of these is in the Quincy Mine,* built down an incline shaft of 54° to 56° dip, to a depth of about 1450 feet. This contrivance con-

* See isometric view of man-engine.

sists of a pair of rods made of Norway Pine eight or nine inches square, the pieces of timber being 20 feet or more in length, and joined together by strong iron plates till the rods are 650 to 700 feet long; below this depth to that of 1450 feet there is another similar pair. At distances of ten feet apart platforms are placed, so that when they come opposite to each other, and there is a temporary pause, the men on those of the one rod step across to the platforms on the other, constantly ascending or descending as desired; the platform being only large enough for two men to pass. At the surface each rod is connected to adjacent ends of two gigantic bobs or walking beams, each of 30 feet in length. These two bobs are connected together by a strong wooden shaft, and are attached to the steam-engine gearing and worked so that the ends (two or three feet apart) have a reciprocating movement of ten feet; consequently any force tending to pull one bob down (as the rod loaded with men) will tend to lift the other (or the unloaded rod). Now the two rods are thus balanced, and in order to lift men from the mines, only the amount of steam to overcome their weight and the friction of the machine is required. This is the principle, but in practice the rods which come to weigh many tons, must be further balanced, and also the friction existing between them and the inclined foot wall must be relieved. About every twenty feet apart there is a pair of flanged wheels attached to the rods and moving on rails, while at every 50 or 100 feet there are permanently attached grooved wheels, over which pass wire ropes or chains attached to both rods, and thus the dead weight of each section is locally balanced, and the upper part of the rods and the bobs are not subjected to an almost breaking strain. Again, by means of the break in the continuity of the rods above noticed additional equilibrium is given to the whole contrivance; for here the rods of the lower half of the *man-engine* are attached to another set of bobs at the opposite ends to those to which the upper set is attached; and thus when the rods are completely loaded the men on the upper 700 feet going in one direction tend to balance those on the lower 700, going in the same direction, and only the friction of the parts has to be overcome by the steam, besides the great weight of each rod being broken into two parts. The *man-engine* makes four strokes per minute, there being a pause at the end of each. The whole construction is very costly, but it is the best means of transporting the men to and

from the workings ; for although cars may run up very quickly even from a great depth, yet but few can ascend each time, while with the *man-engine* a constant line of men is ascending, and a mine can thus be cleared of 200 to 500 men more quickly than by other means. Moreover if the machine breaks it cannot fall more than 10 feet, or perhaps not at all.

Almost all the steam engines in the Lake Superior Copper region are high-pressure and are attached, either directly to the winding drum, or else have friction gearing.

Most of the copper mines are comparatively free from water, and what does find its way into them is chiefly from the surface, or from the upper levels. Consequently the pumps—which are *plungers*—are relatively small, and the expense of working is inconsiderable. The plungers are usually placed at every 200 to 300 feet apart, with cisterns, and so the great pressure of the columns of water is avoided, and the cost of construction of stronger pipes much reduced. In some of the mines the lower levels do not of themselves contain enough water for mining purposes.

As noticed before, the mines are cool, and out of the leading draughts of air, have an average winter and summer temperature of 60° Fahr. Artificial ventilation is seldom resorted to, unless it be to change the current of air in a shaft from down-cast to up-cast. Most of the mines have adits or shafts of unequal height, and sufficient air naturally circulates, as long as the connections are good. In winter, doors require to be placed in some of the passages, the currents of air becoming too rapid, as the difference of temperature at the surface and in the mine is very great, the thermometer at the surface sometimes indicating from 30° to 47° below zero.

When the rock brought to the surface is taken to the rock-house, it is hand-picked, and the poorer portions rejected. After the larger masses are broken up by steam-hammers, the whole of the cupriferous rock is put through Blake's rock-breakers and crushed to a small size, after which it is sent to the stamp mills. The larger pieces of copper that can be detached from the rock by hammers are cleaned and shipped as *barrel-work*, but they usually contains as much as ten per cent. of gangue. Under the stamp the rock is crushed in presence of water, and washed through sieves having holes a quarter of an inch in diameter. The fine material is washed down into hydraulic separators called *jiggers* (Collom's

or Sherman's Patent). The principle of these jiggers is that there is a piston box divided into two compartments connected with others in which there are sieves, and over these the water laden with powdered rock flows. A downward sharp motion is communicated to the pistons which forces the water to rise up slightly through the sieve-boxes, on which the heavier and coarser material has settled, thus loosening it. By this means the finer particles of the heavier rock and copper pass through the sieves into the compartments below, whence they are washed down and are farther separated on other sets of jiggers. But the larger portion of the finer rock is carried off the sieves with the over-flow of water. By continuing this operation a mineral of 80 to 88 per cent. of copper is obtained in small grains. The refuse from the jiggers is worked over on *percussion-tables* and in *tossers*, or else on convex or concave (English) *buddles*, by means of which an additional quantity of fine copper is saved. At best 20 to 40 per cent. of all the copper is lost in the concentration, the larger loss being caused by the particles of metal being more or less flaky. For some distance about the stamp-mills the water in the lake below has a copper color, derived from minute particles of the metal held in suspension.

Three different kinds of stamps are used on the Keweenaw Peninsula. The first is the square headed stamp weighing from 900 to 1100 pounds, and falling 16 to 18 inches by its own weight, four heads working in each *battery*, which is capable of crushing 12–14 tons of rock in 24 hours. The second kind is Ball's patent stamp, the shoes of which are oval. Together the heads and shafts weigh from 2000 to 2200 pounds, the whole being lifted two feet and forced down by a high pressure of steam in a cylinder at the upper end of the shaft, and in the meanwhile the stamps are made to revolve. Each stamp is capable of crushing more than 100 tons of rock per day (24 hours). The third kind is the *atmospheric stamp*, of which there are six heads to a battery. To each stamp there are engine fittings just above the shoes, for compressing the air, and all six are attached to cranks on a common shaft. Although each stamp complete weighs only 200 to 300 pounds, the quantity of work done per day is comparable to that accomplished by Ball's stamp under the same amount of steam. The shoes are usually made of white iron, and last six or seven days with Ball's stamp, while with the others they last 21 to 30 days before being worn out. Each of those of Ball's patent is allowed 20 jiggers.

The large masses of copper are usually detached in the mines by blowing down all the surrounding rock, after which they are cut up into portable masses of 4 to 7 tons, by means of chisels less than an inch wide, making long grooves through the masses, after which they are brought to the surface and the attached pieces of rock are removed as far as practicable. The masses of copper together with the concentrated *mineral* are smelted alone in reverberatory furnaces (of which there are seven) at Portage Lake or in Detroit. The slag rich in copper is again smelted with lime, in Mackenzie's blast-furnaces, and afterwards the impure copper (containing iron) is re-smelted in the reverberatory furnaces; and the waste slag from the cupolas retains less than one half a per cent. of copper. Eight to ten hours are usually required for each charge of 10 to 16 tons of mineral to be smelted; of this time two or three hours are given to poling in order to render the copper tougher.

After the appearance of the report of Dr. Houghton in 1841, and for several years following, a wild mining fever seemed to have been caused by the discoveries in the Lake Superior Region; for at the close of 1845 no less than 61 mining companies were organized, of which 12 had commenced active operations, all expecting to become suddenly wealthy. During 15 months ending with November, 1845, no less than 592 mining locations were granted by the Government to nearly as many persons. Although eventually there were 111 mining companies formed, whose locations spread over the whole length of Keweenaw Peninsula, a smaller number commenced work, as many of them found they had "mining permits" without mineral. Of all those that did begin operations and have since been organized, only nine have paid dividends, and with one or two exceptions these nine have paid handsomely, and now three or four more, after a long struggle, are promising to become lucrative. Some of the failures have been the result of working lodes too poor to pay, and moreover, in the early history of these regions, a great deal had to be learned, as the percentage of copper is small and in a different form from that of any other copper mining region, and the necessarily great economy in working and handling the rock was unknown. So great is the economy now that some mines can win the rock, break and stamp it, concentrate and smelt the copper for $3.50–$3.75 per ton for all the rock broken. Other failures were due to gross mismanagement, and waste of money,

whereby not only all the original capital, but also all the earnings have been squandered. Some mines have been worked for 20 years, but, in all that time, only enough copper has been won to keep them open, and now we find nearly a score of mines where work is being carried on but not paying dividends. Since 1845 over 200,000 tons of copper have been extracted, having realized $90,000,000, and the present annual yield is not far from 19,000 tons. As far as known the assessments on the shareholders have been about $20,000,000, leaving seventy millions more which have been spent in extracting the copper, making improvements, and in paying dividends, by which some of the companies have been handsomely reimbursed. The mining population required to obtain this amount of copper, including the families and those indirectly living by the mines, is nearly 25,000 persons, scattered over three principal centres—Portage Lake, Keweenaw County, and Ontonagon County, besides a small population on Isle Royale.

The Calumet and Hecla Mines, discovered about 14 years ago, are situated 13 miles north of Portage Lake. The original sum paid into the company was $800,000 ; and since that time $9,000,000 have been paid in dividends. This lode yields 4 per cent. of copper. The Minnesota Mine in Ontonagon County paid $1,700,000 over the original capital paid up, and when nearly exhausted, it was sold for $2,000,000 more. The other mines, which have paid handsome dividends, are the Quincy, Franklin and Pewabic, on Portage Lake ; the Cliff, Central and Copper Falls, in Keweenaw County, and the National in Ontonagon County.

Only about 1.15 to 1.25 per cent. of all the rock broken, (or 23 to 25 pounds per ton) at the Quincy Mine is copper ; yet by economy and skilful management the mine has paid upwards of $1,800,000 in dividends, while the paid up capital amounted to only $200,000, and about $600,000 more were taken from the winnings to make necessary improvements on the property.

The quantity of copper in the Lake Superior region may be considered inexhaustible. Hundreds of valuable veins, as well as beds, exist, on which no work has been done, and on both sides of the lake many of these are awaiting future development, for which large capital will be required before success can be hoped for. Recently on Isle Royale, promising discoveries have been made. On the Canadian side there have been few attempts at copper-mining, but in the future the lessons learned by our

American friends will be a guide. Yet the metal must be paid for, as riches cannot be picked up in the streets.

On Isle St. Ignace, at Mamainse, Point Aux Mines, and on Michipicoten Island, the copper-bearing rocks particularly resemble those on Keweenaw Point, and appear to be as promising. Some small workings have been carried on on Michipicoten Island, but these have not been sufficiently extensive to more than prove the presence of copper in considerable quantities. In a report of Dr. T. Sterry Hunt to the Quebec and Lake Superior Mining Association, he speaks very strongly as to their probable value, and from my own experience in the various copper mining localities on Keweenaw Point, and the comparative value of such cupriferous rocks of Michipicoten Island as I have seen, I look forward to the time when the development of these Canadian mining localities will also be none of the least important of those in the Lake Superior region—already the richest copper mining region in the known world.

Appendix.—After the former part of the present paper was in print, Principal Dawson kindly referred me to a paper of his published in 1857, relating to the cupriferous series in the region of Maimanse, on the North Shore of Lake Superior.

Although written at an early date in the history of geological knowledge in that region, I was struck with the descriptions of the rocks under consideration, and could almost have imagined that he had a section of Keweenaw Point before him, so similar is the lithological and geological structure in this locality to that on the South Shore; and I think the evidence quite sufficient to prove the rocks both here and on Michipicoten Island to be a continuation of the same part of the formation as is exposed on Keweenaw Point. Moreover, Dr. Dawson considered the proofs in the Maimanse region sufficient to establish from stratigraphical grounds that the Copper-Bearing Formation was intermediate between the Huronian and Potsdam (or the St. Mary's) Groups; which proofs have not been found further west on the Canadian Shore.

Again, the same writer points out the comparatively superficial volcanic character of the rocks of the Cupriferous Formation, while those of the Huronian have a deep-seated origin

At Maimanse aboriginal workings have been found, and several years ago a shaft was sunk to a depth of twenty-seven feet, from which three tons of copper were taken, one mass weighing 600 pounds.

NOTES UPON THE SUPERFICIAL DEPOSITS OF ONTARIO.

By D. F. H. Wilkins, B.A., Bac. App. Sc.

Since the publication of the *Geology of Canada* in 1863 and the valuable papers of Prof. Chapman, Ph. D., L.L.D..of Toronto, in 1859 in the Philosophical Magazine, and in 1860 in the Canadian Journal, several interesting facts have been discovered regarding the superficial deposits as far as they have come under the writer's observation in a few localities in Ontario. Thus at Port Rowan, near Long Point, Walsingham Township, Norfolk County, we have the following facts revealed.

First.—As to the succession from below upwards.

(1). An unknown thickness of blue calcareous Erie clay, generally free from boulders and containing in its upper layers a few leaf-impressions, apparently of the birch, the maple, the elm and the poplar. The maximum thickness of this is said to exceed five hundred feet, this thickness having been bored through in 1866 in the vain hope of finding oil. As, however, the soft gray marls of the Hamilton formation must occur about this locality, Port Rowan standing nearly over the line between it and the underlying Corniferous, it is possible that some of these marls may have been penetrated.

(2). About two feet of quicksand.

(3). Twenty feet, on an average, of brown calcareous clay, stratified, as also is (1), and destitute even of leaf-impressions. It contains very many rounded Laurentian, (both Upper and Lower.) and Huronian, fragments and angular fragments of the Corniferous limestone holding its characteristic fossils.

(4). About a hundred and twenty feet of stratified, lacustrine sand, often containing grains of magnetite. It is almost destitute of boulders and pebbles.

Secondly.—As to the distribution of these. In proceeding eastward from Port Burwell to Port Rowan the sand is seen to lie at the surface, and in one or two places along the line of the

stage-road, is seen reposing upon the clay. In Bayham Township, Elgin County, about three miles north-east from Port Burwell, a large bed of bog iron ore is found on the property of the late A. McLennan, Esq., of Port Rowan. North from Port Burwell to Tilsonburg, the brown clay is said to be met with near Vienna, occupying the hollows. At lot 17, Con. I. Houghton Township, on the farm of Mr. George Fuller, were found, some years ago, the remains of a mastodon, viz: two teeth, a femur and some tarsal bones. They were discovered two feet from the surface in a swamp. Near here, about a quarter of a mile west of the Village of Clear Creek, the clay (3) escapes from under the sand and constitutes the soil in the south part of Walsingham Township. The line subdividing the clay from the sand crosses the Town-line between Walsingham and Houghton Townships about two and a quarter miles due north of Lake Erie, or a little north of the Second Concession line in Walsingham Township. The sand occupies a breadth of about two miles along the second Concession line and advances in a tongue or spit ending N. 70° W., diminishing to a quarter of a mile in width at Concession B. and thinning out near Port Royal, on the west side of Big Creek. The sand is met with again on this line about five-eighths of a mile west of the Walsingham plank-road, and here has a breadth of a mile. Between these two places and beyond the mile eastward just mentioned, it recedes to the third Concession and disappears on the "Three-quarter Town Line" in their localities one a mile north of the other, the latter being near the second Concession. The line crosses the Charlotteville "Townline West" at the second Concession of the latter township, and ending eastward, appears on the lake, on a hillside on the south-west bank of Barnum's Creek, near Turkey Point, Long Point Bay. On the fourteenth Concession of Walsingham Township, a mile east of the Plank Road, is a workable bed of stratified gravel, and near the fifth Concession on the Plank Road is a lenticular bed of poor limonite twenty feet in thickness. It has been worked over an area of fifteen acres and is employed for the manufacture of pigments. It may also be mentioned that there are two dunes or hills of blown sand, containing so much magnetite as to perturb the compasses of passing vessels if they approach too near the shore. They are three hundred feet high, and occur half a mile south of the "Lake Shore Road" in Houghton Township, about six miles east of

Port Burwell, and fourteen miles west of Port Rowan ; they are immediately upon the lake shore. The Township of Charlotteville is occupied almost altogether by sand, as is also Woodhouse. In Charlotteville, near Normandale, are several thousand acres of blown sand, the only vegetation upon which consists of a few stunted grasses, the *Phlox subulata*, *Viola cucullata* and *Polypodium vulgare*, and some scrub oaks and dwarf pines. These "oak plains" as they are called, are perfectly valueless for agricultural purposes. On page 185 of the *Geology of Canada*, 1863, will be found a notice of the bog iron ore beds of this township.

Proceeding to North Norfolk and South Oxford it is found that the sand is here at the surface. It is unstratified and in Windham, Burford, Townsend and Oakland Townships it also seems to be unstratified and *to have been derived entirely from the subœrial* denudation of the Oriskany sandstone and Corniferous limestone. In Middleton Township, Norfolk County, the sand is met with also and in some localities in the former township stratified gravel. A somewhat peculiar feature—the dead forest—is met with in Dereham, Middleton, Bayham and Malahide Townships. In the summer of 1845 the pine trees in this region all died. Near Waterford in Townsend Township stratified gravel is met with, while further north, both south and north of Brantford the Erie clay is seen to re-appear. It is not only seen in a brickyard south of the town, but also north along the cutting of the Harrisburg and Brantford Railroad which was completed in 1871. At both localities the layers are contorted and corrugated. In Walpole Township, especially at Jarvis, the brown clay occurs at the surface.

Proceeding eastward from Paris the sand overlies the blue clay and forms the "plains" of Brantford Township. From near Rosebank along the Governor's Road east nearly to Lynden, the brown clay appears, and in the valley of Fairchild's Creek is seento be stratified, and to overlie the stratified blue clay. Near Troy in Beverly Township the calcareous blue clay is met with, stratified and overlaid by the stratified brown clay and sands. Thus this brown clay is apparently the stratigraphical equivalent of the stratified brown clay at Port Rowan. On the second concession of Ancaster Township the clay contains calcareous concretions and is here, about lot No. 7, overlaid by the sand. The sand is met with to lot No. 23, when the clay re-appears for a short distance. Approaching the edge of the Niagara escarp-

ment the gravel ridge is met with which is the watershed dividing streams flowing into Lake Ontario on the north from those flowing southwest to the Grand River. This watershed rises in Binbrook Township, Wentworth County, not far from the Grand River and trends N. W. to Copetown, Ancaster Township, through Binbrook, Glanford and Ancaster Townships. It then sweeps round the head of the valley and trends north-east. It contains great numbers of boulders of Hudson River or Cincinnati age of the lithological character given on page 212 of the *Geology of Canada*, 1863; at the same time it holds few, if any, Medina Clinton or Niagara remains, and is stratified.

The valley at Hamilton, Ont., is occupied by Medina red shales and sandstones. The iron in upper layers has been deoxydised by organic matter prior to the deposition of the stratified sand thereon, and the blue calcareous clay is evidently wanting. This is seen abundantly at different localities along the edge of the marsh near the Toronto branch of the Great Western Railroad, immediately east of the eastern city limits on the main line of the G. W. R. R., and towards Dundas west of the city. The Medina shale, is otherwise unchanged in appearance, showing *that the change is due to organic matter only*. The beautiful valley now occupied by Burlington Bay is, as Mr. J. W. Spencer, Bac. App. Sc. has shown, protected by two sand-spits in which beach structure and wind drift structure are plainly seen. These are rudely parallel, the western one being called Burlington Heights and reaching a hundred and fifty feet in height, marking of course an ancient lake-level. A still more ancient margin can be observed, and is very distinctly seen at Dundas. West of Dundas to Copetown, the valley is occupied with hummocks of sand and clay, the latter underlying the former. A ridge of gravel leaves Burlington Bay on the north shore and trends north-eastward crossing the Toronto branch, of the G. W. R. R. half-a-mile east of Waterdown Station. Near the G. W. R. R. bridge on the west bank of the Twelve mile Creek, near Bronte Station may be seen a bed of gravel occupying a hollow in the Medina sandstone.

The valley of Burlington Bay at Hamilton was formed as shown by Mr. Spencer by the erosion of several streams, though the primary form of the valley is doubtless due to the fact that the strata of the Niagara group fold over an anticlinal, and that hence the valley would occupy the crown of the arch, *cæteris*

paribus. The stream referred to drained an ancient lake, known to the "oldest inhabitant" as the Beverly Swamp. This occupies a space of ten miles from south to north (Concession IV. to Concession XI.) and from the town-line west of Beverly through Beverly, West and East Flamboro' inclusive E. to W. "Crook's Creek" flowing from this evidently contributed most to the formation of Burlington Heights. The swamp is crossed by several gravel ridges or eskers, with an E. and W. strike. They are stratified and average a hundred feet in height, containing large numbers of rounded boulders of the underlying Guelph limestones. Niagara *débris* is, as Mr. Spencer says, almost unknown among the boulders and pebbles of all the deposits in the south western part of the Western Peninsula of Ontario.

North of Beverly in Puslinch and Guelph Townships, and as far west as Colborne and Goderich Townships, numerous other eskers are visible, some having a N. W. and S.E. strike, some N. and S. S (*e .g.* Smith's Hill, Colborne Township, and a parallel ridge a mile east,) and some E. and W. Between the eskers the country is often swampy. The eskers are all stratified.

Except the striæ in Beverly and Barton Townships there is no evidence of either glacial or iceberg action near Hamilton, Ont. Several new exposures have been made visible in the Guelph limestone of Beverly since the visit of the Geological Survey officers. One of these, half a mile north of Con. V. and north of Rockton, near to one of the gravel ridges mentioned in the second paragraph above showed striæ N. 70° W. while at Rockton, two miles away, the striæ were N. 79° W. on the roadside. At Sheffield *three* sets of striæ occur, the most ancient being N. 75° W., then N. 75° E. and N. 40° E. Near Troy are two sets of striæ N. 76° W. and N. 70° E. running North of Rockton a mile north of the first exposure are striæ N. 70° E.

NOTE ON THE GEOLOGY OF THE LABRADOR COAST.

By D. F. H. Wilkins, B.A., Bac. App. Sc.

During the past summer a flying visit paid to a few localities on the Labrador Coast enabled the writer to assert that what has been alleged by Mr. Richardson of the Geological Survey, concerning the stratigraphy of the Laurentian rocks between the Bersimis and the Saguenay Rivers, is generally true concerning the rocks further north-eastward, at least at the few places visited. The Lower Laurentian gneisses and diorites are invariably fractured and cleaved in all directions, and intersected by several fissures and some trap dykes, with a, generally speaking, north-easterly strike. The stratification lines are very often so obscure that it is almost impossible to say whether the rocks are metamorphic or eruptive. On these are superposed unconformably the Upper Laurentian gneisses and norites with hyperites, and in one locality, a bed of micaceous sandstone, all dipping at moderate angles, lying in synclinals having, so far as examined, dips ranging from 26° 10′ to 63° 26′ and an E. and W. to N. 45° W. strike.

Thus at Little Mecattina River outlet, Upper Laurentian, red-weathering, gray hyperyte in a bed two feet thick, overlaid by four feet of whitish gneiss with a dip N. 70° W.$\lessdot$49° and strike N. 20° E., is seen to repose, at low tide, upon the underlying red gneiss of Lower Laurentian age. At Baie des Moutons, eighteen miles north-east of this, Lower Laurentian firm, coarse-grained, red gneisses appear, intersected by cleavage-planes and fissures, and fine-grained, red, granitic veins, the older set having a strike N. 47° E. and intersected by the newer set which strike N. 87° W. A fine example of a trap dyke can be seen from the ocean at Schooner Bay, three miles north-east of Baie des Moutons. Its strike is apparently N. 50° E, and its maximum thickness is six feet, diminishing to three feet. At the mouth of the river St. Augustine, about fifteen miles from the mainland, on L'Isle aux Sables occurs the bed of micaceous sandstone already referred to. It is tender and friable, brownish-grey in colour, and lies in a synclinal with a N. 45° W. strike.

The dip on the south side of the beds, where it is more friable than on the north, is to the N. E.<61°, while on the north side it is to the S. W.<58°. At L'Isle du Lac Salé about three miles nearer the shore, the Upper Laurentian rocks are seen to lie in a synclinal striking N. 10° W. and dipping N. 80° E.<63° 26' on the south-west side, and S. 80° W.<54° on the north-east side, about four miles across the strike. They rest upon black diorites and consist of twenty-nine feet of grey norites and thin red gneisses overlaid by gneisses which are mostly concealed by vegetation. The bed of micaceous sandstone referred to is intercalated between an unknown thickness of white gneiss below and about a thousand feet of reddish gneiss above.

NEW AND INTERESTING INSECTS FROM THE CARBONIFEROUS OF CAPE BRETON.

By Samuel H. Scudder, of Cambridge, Mass.

Dr. J. W. Dawson has placed in my hands a piece of carboniferous shale from Cape Breton, containing remains of several insects. The best preserved and most interesting is the abdomen of a larval Dragon-fly. Odonata, both mature and in their earlier stages, have previously been found in the Jurassic beds of Solenhofen; wings and fragments of other parts have also been found in the English Lias, and a specimen, which may be an odonate larva, has been figured by Brodie from the Oxford Clay. No true Odonata, however, have been discovered so low as the carboniferous formation, unless the obscure fossil, thought by Goldenberg to be possibly a Termes,* may properly be referred to this group.

In the last edition of Dr. Dawson's Acadian Geology, however, I have described (p. 387) the wing of an insect, *Haplophlebium Barnesii*, which certainly bears some striking resemblances to the Odonata, and of which it is not impossible that the present fossil may be the larva.

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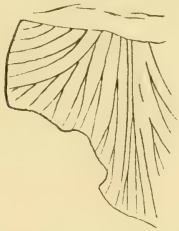
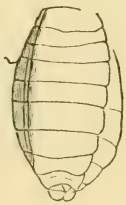
* See Dunker and Meyer's Palæontographica, iv, pl. vi, fig. 8. Subsequently (Vorw. Faun. Saarb. 12) Goldenberg refers this definitely to the Termitina, under the name *Termes* (*Calotermes*) *Hageni*.

The abdomen of the specimen (fig 1) is nearly perfect, and presents a ventral aspect, portions of the flanks of the body may

Fig. 1. Fig. 2.





be seen on either side; upon the left side in direct continuity with the ventral segments and very distinctly, especially since this region is darker colored than the other parts of the abdomen. The limitation between the ventral and pleural portions is sharply defined on this side by slight ridges, showing that in life these parts were abruptly limited, while the margination of the extreme border of the fossil shows that, as in living odonate larvæ, the dorsal was again separated from the pleural region of the abdomen by a distinct bend. The abdomen is elongate-ovate, devoid of any armature, composed of nine segments, the ninth obscure and bearing a pair at least of rounded lobate pads of considerable size, but not as in recent Odonata, pointed at the tip. The second to the fifth segments are shorter than the others; the posterior edge of all the segments is straight, excepting that of the seventh, that is gently convex, and that of the eighth, which is strongly and roundly excised; that of the ninth appears also to be regularly concave. The entire entire length of the abdomen is 13.5^{mm}, and the width of the fifth or broadest segment 6.5^{mm}, counting only the ventral portion; the appendages are 1^{mm} long.

It is impossible to say to which group of Odonata the fossil belongs. The Agrionina, are, however, unquestionably to be excluded. It seems to be most probably one of the Libellulina, and may be provisionally placed in the old genus Libellula (which formerly contained all the Odonata) and bear the name *Libellula carbonaria*.

Accompanying this interesting fossil is a frond of Alethopteris and two fragments of wings of cockroaches. One of the latter is too insignificant to be worth noticing, but the other is sufficient for determination, and may be called *Blattina sepulta* (fig. 2).

It appears to be nearly allied to *B. carbonaria* Germ., but differs from it in some important particulars. It is very imperfect, a portion of the outer border being the only part of the margin which is preserved, but most of the disk of the wing is present; probably the entire wing measured nearly 15^{mm} in length; the fragment that remains is but 6.25^{mm} long and 5^{mm} broad. The anal nervure is no more deeply impressed than the others, rather regularly curved, and itself emits several branching and simple shoots from its posterior border; the anal field (and apparently also the middle field) is covered with very frequent cross-nervules, not represented in the figure; the branches of the middle field appear to be not very closely crowded, distinctly less so than those of the costal field.

The fossils were obtained at Cossett's Pit, near Sydney, Cape Breton, by Mr. A. J. Hill, C. E., from "near the horizon of the Millstone Grit," as I am informed by Principal Dawson.

ON A COLLECTION OF PLANTS FROM BRITISH COLUMBIA, MADE BY MR. JAMES RICHARDSON IN THE SUMMER OF 1874.

By G. Barnston.

The collection of which the present paper is a catalogue can scarcely fail to be of interest to the botanist in Canada, as it is probably the first brought to Montreal from that distant portion of the Dominion.

Forty-three of the species are from the vicinity of Victoria, the capital of Vancouver Island, and some of them give evidence of the near approach to the genial climes of Washington and Oregon Territories, those picturesque regions whence many of the floral beauties which adorn the gardens of the wealthy both in England and in this our own land were originally obtained.

McLaughlin's Bay (or Bella Bella) on Campbell Island, a Hudson Bay Company post and Indian village, is the next locality, and has furnished forty-seven plants to the collection. The latitude of this place is about 52° 10′ north, and the longitude is about 128° 10′ west of Greenwich; but the flora would seem to indicate that the temperature during the summer months is about the same as at Montreal.

The remaining localities from which specimens were obtained are Gardner's Channel, Kamino River and Mountain, Kitimat Inlet and River.

These rocky and deep inlets represent fully two degrees of latitude; but, at least along the lower elevations skirting the shores, afford the same flora throughout. About forty species were collected on them, not including about fifteen repetitions of plants found at the first mentioned localities. To them may also be added eight or nine grasses gathered in the Kitimat country.

Out of one hundred and twenty species about thirty pertain strictly to the Western flora, and are not known to occur east of the Rocky Mountains; the rest, however, may be met with east of the mountains in various localities, some on the prairies or along their borders, and others in the wood d regions. Five or six species may be classed among the sub Arctic plants, viz., one *Menziesia*, two *Andromedas*, *Saxifraga Aizoon* and *S. æstivalis*. It may be remarked that the *Andromeda cupressina* (Hooker) which occurs among the Kamino plants and which is apparently confined to the mountains of the Pacific slope, is closely allied to, yet essentially different from, the *Andromeda tetragona* of Baffins Bay and the Arctic coast. The latter was the plant upon which Dr. Rae relied for fuel when he wintered in the Esquimaux country at Repulse Bay.

The botanists of Montreal should feel greatly indebted to Mr. Richardson for this contribution to their knowledge of the Pacific coast flora, and for his still untiring assiduity in the pursuit of scientific objects; the more so as botany is not the particular branch of science in which he is officially engaged.

LIST OF SPECIES.

Near Victoria, Vancouver Island, May 1st to 10th.

Ranunculus recurvatus, Bong. Hooked Crowfoot.
R. occidentalis ? Nutt. M. S. S.
Delphinium Menziesii, De Candolle.
Cardamine angulata, Hooker.
Capsella bursa pastoris, Linn. Shepherd's Purse.
Viola rotundifolia, Michx. Round leaved Violet.
" *cucullata Ait., var. cordata.*
Cerastium arvense, Linn. Field Chickweed.
Claytonia alsinoides, Sims. (= *C. Unalaschkensis*, Fischer.)
Calandrinia Menziesii, Hooker.

Cytisus sarothamnus, Linn. The Broom. Naturalized.
Trifolium microdon, Hooker & Arnott., (fide Macoun).
Psoralea argophylla, Pursh. In its early state.
Lathyrus venosus (Muhl.) var. D. (= *L. pubescens*, Nutt.)
" *decaphyllus*, Hooker.
Potentilla nivea, Linn., var. G. (= *P. hirsuta*, Vahl.)
Ribes spectabilis, Pursh.
Ribes sanguineus. Pursh.
Saxifraga integrifolia, Hooker.
" *ranunculifolia*, Hooker.
Thaspium pinnatifidum, Gray.
Seseli leiocarpum, Hooker. (*Peucedanum*, Nuttall.)
Plectritis congesta, Hooker & Arnott, var. *B. multiflorum*.
Bellis perennis. Linn. European Daisy. Introduced.
Helianthus multiflorus, Linn. (Or *H. decapetalus*, Linn., var. *multiflorus*.)
Achillea tomentosa, Pursh.
Armeria maritima, Willd.
Dodecatheon integrifolium, Michx.
Trientalis latifolia. Hooker.
Aphyllon uniflorum, Torrey & Gray. One-flowered Cancer-Root.
Mimulus luteus. Pursh. (= *M. guttatus*, DeCandolle.)
Ilysanthes gratioloides, Bentham. (=*Lindernia dilatata*, Michx.)
Veronica serpyllifolia, Linn. Thyme-leaved Speedwell.
Castilleia hispida, Bentham. (M. S. S.)
Myosotis Chorisiana. Hooker.
" *fulva*, Hooker & Arnott.
Rumex acetosella, Linn. Field or Sheep Sorrel
Arethusa bulbosa. Linn.
Corallorhiza Mertensiana, Bong.
Smilacina stellata, Desf.
" *bifolia*, Ker.
Erythronium grandiflorum, Pursh. var. *B., albiflorum*.
Brodiea congesta, Smith.
Fritillaria lanceolata, Pursh.
Uvularia puberula. Michx. (= *U. lanuginosa*, Pers.)

From Campbell's Island (locally known as Bella Bella,) May 26th.

Caltha natans, Pallas.
Arabis hirsuta, Scopoli.
Drosera rotundifolia, Linn. Round-leaved Sundew.
" *longifolia*, Linn.
Claytonia alsinoides, Sims. (= *C. Unalaschkensis*, Fischer.)
Geum macrophyllum, Willd.
Rubus odoratus. Linn. (Purple Flowering-Raspberry.)
" *obovatus* ? Hooker : or *pedatus* ?
Amelanchier Canadensis, var. botryapium. (Shad-bush. Service-berry.)

Ribes bracteosum, Douglas.
Heuchera micrantha, Douglas.
Cornus Canadensis, Linn. (Dwarf Cornel. Bunch-berry.)
Sambucus pubens, Michx. (Red-berried Elder.)
Viburnum pauciflorum, De La Pylaie.
Vaccinium uliginosum, Linn. (Bog Bilberry.)
Arbutus Menziesii, Pursh.
Gaultheria procumbens, Linn. (Creeping Wintergreen.)
Kalmia glauca, Ait. (Pale laurel.)
Ledum palustre, Linn
Pinguicula vulgaris, Linn. (Butterwort)
Trientalis arctica, Fischer.
" *latifolia*, Hooker.
Gentiana Douglasiana, Bong.
Spiranthes cernua, Rich.
Smilacina bifolia, Ker.
Erythronium grandiflorum, Pursh : var.
Eriophorum polystachion, Linn.

FOG ROCKS, MAY 28TH.

Potentilla villosa, Pallas.

GARDNER'S CHANNEL.

June 1st. *Claytonia alsinoides*, Sims. (= *C. Unalaschkensis*, Fischer.)
Carex Barrattii, Fischer.
" 3rd. *Thaspium atropurpureum ?* (Or *Sanicula Menziesii*, doubtful.)
Potentilla anserina, Linn. (Silver-Weed.)
" 4th. *Ranunculus cymbalaria*, Pursh. (Sea side Crowfoot.)
Actæa rubra, Bigelow. (Red baneberry.)
Lonicera involucrata. (Herb. Banks.)
" 5th. *Aquilegia formosa*, Fischer.
Amelanchier Canadensis, var. *botryapium*.
Aralia racemosa, Linn. (narrow leaved variety.)
" 7th. *Smilacina racemosa*, Desf.
" 9th. *Saxifraga aizoides*, Linn. Yellow Mountain Saxifrage.
" 10th. *Campanula rotundifolia*, Linn. (Harebell.)
Gaultheria procumbens, Linn.

KAMINO RIVER.

" 15th. *Lupinus polyphyllus*.
Rosa fraxinifolia, Bork.
Saxifraga æstivalis, Fischer. (= *S. heterantha*, Hooker.)
Bulbiferous.
Stachys ciliata, Douglas.
Gentiana saponaria, Linn. (Soapwort Gentian.)
" 16th. *Andromeda cupressina*, Hooker.
" *polifolia*, Linn. Kamino Mountain.
Kalmia glauca, Ait.

June 17th. *Menziesia Grahami*, Hooker. (An ? var. M. *empetriformis*.) Stigma exserted.
" 17th. *Lathyrus maritimus*, Bigelow. Gardner's Channel.
" 18th. *Lonicera involucrata*. (Herb. Banks M. S. S.)

Clio Bay.

" 21st. *Corydalis glauca*, Pursh. (Pale Corydalis.)
Tellima grandiflora, Douglas.
Dodecatheon intergrifolium, Michx.
Glaux maritima, Linn. var. (Sea-Milkwort.)
Erythronium grandiflorum, Pursh. Var. A : minor.
Tofieldia glutinosa, Pursh, var. *purpurea*. (Like *T. coccinea*.)
Panicum dichotomum, Linn.

Kitimat.

July 1st. *Cornus stolonifera*, Michx. (Red-osier Dogwood.) Inner Harbour.
Andromeda cupressina, Hooker. Near snow.
Kalmia glauca, Ait. Kamino Mountain.
Pyrola secunda, Linn. (One-sided Pyrola.) Inner Harbour.
Menyanthes trifoliata, Linn. (Buckbean.)
Polygonum viviparum, Linn. (Alpine Bistort.)
" 2nd. *Tiarella trifoliata*, Linn. Kitimat Village.
Thaspium ? atropurpureum, Nuttall. (Or *Sanicula Menziesii* : doubtful.)
Achillea tomentosa, Pursh.
" 15th *Brassica campestris*. Wild Turnip. Introduced.
Claytonia perfoliata, Donn.
Epilobium angustifolium, Linn. (Great Willow Herb.)
" *opacum*, Lehm.
Sanicula Menziesii, Hooker & Arnott.
" *bipinnatifida*, Douglas.
Heracleum lanatum, Michx. (Cow Parsnip.)
Plectritis congesta, Hooker & Arnott. Var. B.
Antennaria margaritacea, R. Brown. (Pearly Everlasting.)
Hieracium. Undetermined.
Eriogynia pectinata, Hooker. *Spiræa pectinata* of Torrey.
Pedicularis ornithorynchus ?
Luzula campestris, var. (= *L. congesta*, Lej.)
Agrostis scabra, Willd. (Hair Grass.)
Calamogrostis Canadensis, Beauv. (Blue Joint-Grass.)
Festuca microstachys, Nutt.
Hordeum pratense, Huds.
Aira danthonoides, Trin.
Hierochloa borealis, Rœm & Schultes. (Vanilla or Seneca Grass.)
Phalaris arundinacea, Linn. (Reed Canary-Grass.)

A VISIT TO PORT BLAIR AND MOUNT HARRIET, ANDAMAN ISLANDS.

By Lieut.-Colonel George E. Bulger, F.L.S., F.R.G.S., C.M.Z.S., Etc.
Late H. M. 10th Foot.

In the Bay of Bengal, between the 10th and 14th parallels of north latitude and the 92nd and 94th degrees of east longitude, lie the beautiful tropic islands of the Andamans, known to us since the Indian mutiny chiefly as a penal settlement, but latterly painfully associated in our minds with the mournful tragedy enacted there on the 8th February, 1872.

The Andamans proper consist of four large islands and a multitude of smaller ones, mostly covered with luxuriant forest, and almost everywhere locked in a fringe of coral, which in many places forms extensive reefs, usually so steep and sudden as to be most dangerous of approach. The three largest, called respectively North, Middle, and South Andamans, are only separated from each other by narrow straits, which are not navigable at low water; and hence they commonly bear the one general designation of Great Andaman, in contradistinction to Little Andaman, the name given to the southernmost of the four, which is divided from the others by the broad, deep channel of Duncan Passage.

The larger islands of the group are said to possess many good harbours and anchorages, as well as an abundance of fresh water,* but very little is known about them, as they are not often visited, chiefly, I imagine, in consequence of the danger of their coral reefs and the inhospitality of their inhabitants, a woolly-headed, savage race, whose origin has been for some time, and is still, a puzzle to ethnologists.

Nature has everywhere scattered her beauties over this region with a lavish hand, and some of the smaller rocks and islets are lovely as a fairy dream, counterparts of those bright creations of poetic fancy which Tennyson has drawn for us in 'Locksley Hall.'

> "Larger constellations burning, mellow moons and happy skies,
> Breadths of tropic shade and palms in cluster, knots of Paradise,
> Never comes the trader, never floats an European flag,
> Slides the bird o'er lustrous woodland, swings the trailer from the crag:
> Droops the heavy-blossom'd bower, hangs the heavy-fruited tree—
> Summer isles of Eden lying in dark-purple spheres of sea."

* Rosser and Imray's "Sailing Directions."

Many years ago* the Honourable East-India Company formed a settlement at Port Cornwallis, a noble harbour of the north island, but it was soon afterwards† abandoned on account of its extreme unhealthiness, and, since then, until the establishment of the present penal colony at Port Blair, where the interest of the group is now centred, the Andamans were left to the unrestrained dominion of wild and unfettered nature.

The approach to Port Blair‡ from the northward is very charming—the vessel threading her way through the blue waters of Diligence Strait, with a chain of picturesque islands upon one side, and the so-called mainland on the other ;—all more or less covered with a dense, rich forest, which is usually of the grandest description, and remarkable for the conspicuous, straight stems of its lofty trees. Every summit and every headland seems crowned with these vegetable giants—every valley and ravine is choked with an impenetrable network of thronging branches and irrepressible climbers, and even the very bays and creeks are brilliantly green with the vivid foliage of the mangrove.

During the passage of this exquisite channel, fresh views of the magnificently forest-clad shores are incessantly revealing themselves to the delighted gaze of the traveller—each one wilder, brighter and more fascinating than the last, until their attractions culminate in the superb beauty of Port Blair itself, which is, perhaps, one of the loveliest bays in the whole world. It is a large, irregularly-shaped inlet at the south eastern end of the Great Andaman, indenting the coast to the westward, and then bending downwards to the south. Within its boundaries are most of the settlements of the colony, but the chief station is the little island of Ross, which lies athwart the entrance of the harbour, and, notwithstanding its small size, contains nearly all the principal public buildings, including the church, Government House, and the barracks.

To the westward of Ross, at a distance of rather less than three miles, is another smaller island called Chatham, where a proportion of the convicts are quartered ; and, about the same distance further to the southward—still within the encircling arms of the beautiful sound—the chief prison of the station is reached. It stands upon Viper Island, and is most carefully guarded—a highly necessary precaution, for it contains the very

* 1791. † 1796. ‡ Formerly called Port Chatham.

worst criminals from all parts of India. There are two thriving settlements on the mainland, nearly opposite to Ross, which are known respectively as Haddo and Aberdeen, and several other smaller villages are being established at suitable points further away. On the northern shore of the bay, is Hope Town, and, overlooking this, the sanitarium of Mount Harriet.

The scenery of the long and somewhat tortuous inlet is very attractive throughout its entire distance of seven miles, but its beauty is chiefly due to the presence of a rich and magnificent virgin forest, which, until lately, robed every portion of the visible earth in its vicinity with one living sheet of perennial verdure. Now, however, this glorious jungle has begun to fall rapidly before the axe and the clearing-fire, in consequence of its alleged unhealthiness.

At the southern extremity of the bay is Homfray's Ghaut, and thence, a road, two miles in length, extends to Port Mouat, on the western coast. The land, immediately to the north of this road, is low, swampy and thickly covered with mangroves, but, to the southward, a steep, sloping hill-side flanks it throughout. Here are immense quantities of large and handsome ferns, backed by a grand forest of gigantic trees, whose huge stems are profusely draped and adorned by parasitical and epiphytical vegetation of great luxuriance. Port Mouat consists literally of two bays, which are connected with one another by a narrow passage only ninety yards across. The outer one is open to the sea, and affords no shelter, but the other, which is circular in form, has room enough within its spacious lake-like expanse for the whole of the British fleet. The southern portion is very deep, but it shoals gradually towards the northern-shore, and, as the water is particularly clear, the coral bottom may easily be seen, as well as thousands of splendidly coloured fishes and gorgeous parterres of sea-anemones, whose vivid hues rival those of the iris itself. On a narrow spit of land projecting from the northern shore and close to the little settlement, is a beautiful avenue of cocoa-nut palms, growing in two rows on either hand. These graceful trees, which were planted in 1866, bore fruit for the first time in 1872.

Ross Island is a somewhat bold and rather picturesque triangular mass of rock, consisting,according to Mr. Ball,* of bluish-grey

* "Journal of the Asiatic Society of Bengal" xxxix. 232.

limestone, with interbedded layers of argillaceous shales, rising at its highest point to 195 feet above the sea, and covering an area of about one-third of a square mile ; its length being nearly 1,700 yards, and its greatest breadth—in the centre, where it runs out abruptly into a long projecting point—rather less than the same number of feet. Mr. Ball remarks that, owing to the great inclination of the strata, and other causes, there is considerable risk of destructive landslips ; and if some precautionary measures are not adopted, the eventual stability of the island itself may be endangered, by the removal of stones from the face of the cliff for building purposes, and the disintegration of the exposed surface by the sea and other natural influences.

The indigenous vegetation of Ross has almost entirely given place to ornamental and useful plants, introduced from India, the Malayan Peninsula, and the larger islands. Amongst the trees are cocoa nut palms—which have probably been brought from the Cocos, as they do not appear to be anywhere natives of the Andamans proper—oranges and lemons, with other species of *Citrus ;* the Bullock's-heart (*Anona reticulata*), custard-apples (*Anona squamosa*), guavas (*Psidium pomiferum et pyriferum*), acacias of two or three kinds, including the fragrant *A. farnesiana*, *Agati grandiflora*, *Cassia fistula ;* the Mango (*Mangifera indica*), the Plantain (*Musa paradisiaca*,) and the Durian (*Durio zibethinus*). There are also numbers of small and beautiful trees of *Mesua ferrea*, a noble and gigantic *Calophyllum inophyllum* near the Commissariat office, and, round the coast, occasional fine specimens of the common screw-pine (*Pandanus verus*). Besides these, many flowering plants and a number of so-called weeds, with ten or twelve specimens of grasses, have followed the footsteps of settlement and cultivation, all of which seem to thrive and flourish in the genial climate of this surf-lashed outlying sentinel of Port Blair.

Peacocks of both species (*Pavo cristatus et muticus*), as well as the common Indian crow (*Corvus splendens*), *Estrelda amandiva*, *Acridotheres tristis et fuscus*, and *Palæornis torquatus*, have been introduced since the formation of the colony ; but the amaduvats have disappeared, and the prevailing form of *Corvus* now seems to be *C. andamanensis*, though *C. culminatus* is also found.

Various genera and species of fishes—many of them brilliantly coloured—are abundantly represented in the blue waters of the

bay* ; and rare and beautiful creatures constantly reward the researches of the malacologist, even on the shores of Rose itself; but my personal experience does not extend to either of the branches of natural sicence which include these denizens of the deep, and I must refer those desirous of information on both points to papers scattered over the Journals of the Asiatic Society of Bengal, and Surgeon-Major Day's article on the Fishes of the Andaman Islands, in the Proceedings of the Zoological Society of London for 1870.

The sea was curling up into white-lipped wavelets one day in the beginning of November, 1871, when, accompanied by a brother officer, I crossed the bay *en route* to Mount Harriet, a hill overlooking the harbour, and easy of access from Hope Town, which is a little native village situated in a cove to the westward of Perseverance Point, and nearly opposite to the settlement of Chatham. As we left the jetty at Ross, the dark nimbus clouds which had obscured the morning began to break and give place to a fairer sky, and ere we had completed half our voyage, the truant sun peeped out upon us, and shed such a magic light around, that the superb land-locked inlet, with its

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* The following note may perhaps be interesting as evidence of the rapacity and numbers of sharks in these waters. It is condensed from an account written by a brother officer, whose veracity and accuracy are both unimpeachable.

"The Andaman fishing expedition which you enquire about took place, as you know, during our short sojourn in Port Blair in October, 1871 ; and my companions were five convicts—all natives of India. I had great difficulty in pursuading the official in charge of these men to allow me to accompany them, and it was only on my promising not to ask them to return before the proper time that he acceded to my request. We left Ross about eleven o'clock in the forenoon, and went, in the first instance, to a small settlement upon the main island some few miles to the north-west, where we remained about three-quarters of an hour. It was a pretty little spot, but as the boatmen went ashore and left me to take care of the canoe, I was unable to explore it ; and, indeed, the surf was so great that I do not think I could have landed with any degree of comfort. Thence we proceeded to the fishing-ground, about twenty miles further north, which we reached about 4 p.m. In this vicinity, we remained the whole night and part of the next morning—changing our position occasionally when we found the sport getting slack. The weather during the day was fine and pleasant, but about sunset the wind rose, and the night subsequently proved rather rough and stormy—much to my

picturesque islands and wooden shores, seemed all aglow with gold and amber, while the white breakers dashing over the coral reefs, and gathering force and grandeur at every fresh breath of the sea-breeze, lent such an additional charm to the rich green forest, still dripping and sparkling with pendent rain-drops, that the scenery attained an almost ideal beauty, impossible to describe—so soft—so fresh—so glorious.

> "—— That earth now
> Seem'd like to heaven, a seat where Gods might dwell
> Or wander with delight."

The distance across the bay is rather more than three miles, and it was about eleven o'clock when we landed at Hope Town, on the still unfinished pier, which scarce three months later earned such a melancholy celebrity by the assassination of Lord Mayo.

After a short delay at the village, until the servants arrived with our supplies of food and other impediments, we commenced the ascent by a very good bridle-road of thirteen furlongs in length, which climbs easily and pleasantly through a beautiful virgin forest to the Commissioner's bungalow upon the summit of

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discomfort, for the heaving and tossing motion made me ill, and, as there was no room for me to stretch my legs, I suffered terribly from the cramped position which I was obliged to maintain for nearly thirty hours. We did not get back until 3 p.m. the next day, and the canoe was so small and crank, that I was confident we should not have accompished the voyage in safety, if the boatmen had not been plucky fellows and thoroughly up to their work. I believe all the other fishing parties returned to the shelter of the harbour before it grew dark. We shipped so much water that one of the men was constantly employed in bailing, and even then, we narrowly escaped being swamped. We used ordinary deep-sea lines, and the bait consisted of bits of fish. Those which we caught were from 18 to 24 inches in length, and weighed perhaps between 8 and 14 pounds. I believe they are called cocoa-nut fish, but I regret to say, I knew nothing further about them. Our take would have been very great, had it not been for the sharks, which, in many instances, robbed us of our captives by taking them off the hooks, while they were being hauled in, and leaving nothing but the heads. This was done so deftly and expeditiously too, that the monster's snap was sometimes hardly perceptible. I was so faint when I got back, owing to sickness, the miseries of my awkward position and want of food—plantains and papaws being the only provisions we had with us—that I could scarcely stand."

the hill, 1,185 feet above the level of high tide. Nothing can be more charming than this pathway, winding, as it does, amidst the profuse and irrepressible vegetation of the tropics, and vocal with the many strange and singular sounds with which creation speaks in these voluptuous latitudes. Noble trees of great height and remarkable for their huge buttressed trunks, stand all around like mighty sentinels, and cast grateful shadows from their green canopies of foliage over much of the ascent, tempering the heat and affording shelter to hundreds of gay and often sweet-voiced birds and marvellous insects, which make their home amidst these vast storehouses of nature; while clinging to the giant stems and round the great spreading arms of the patriarchal trees, are myriads of parasitical and climbing plants, rejoicing and luxuriating in the moist warm climate, which though almost free from the oppressive sultriness of the calm regions, possesses much of that fervent life-giving humidity so characteristic of the equatorial zone.

It is not the least of the attraction of this delightful roadway, that in its immediate vicinity a beautiful brook comes dashing down the mountain-side from a perennial spring near the summit, and after a sparkling and rapid journey, falls into the bay near Hope Town.

Escaping a drenching shower on the way by the opportune occurrence of a sheltering rock, we reached the summit of the hill in due course of time, and, taking possession of the Commissioner's house, regaled ourselves with cool draughts of magnificent milk, which appeared to be the only purchasable article within reach, notwithstanding that a considerable portion of the extensive clearing round the bungalow was devoted to the cultivation of vegetables of different kinds. Other houses, inferior in size and aspect to that which we had temporarily appropriated, combined to form a sort of village in this charming locality, which seemed to rejoice in a most cool and pleasant climate, and afforded us such a view as is rarely seen even in the tropics. The panorama unfolded by our elevation embraced a vast extent of sea and land, including Rutland Island and Macpherson's Straits, as well as some of the lofty elevations of the North Andaman, including the Saddle Mountain, which is visible at sea sixty miles away, and estimated to 2,400 feet in height. Almost below us lay the beautiful harbour of Port Blair, with its various rocky islands, and stretching away to the southward, the forest-fringed lagoons leading to Port Mouat.

Mr. Ball, whose interesting paper on the geology of the vicinity of Port Blair* I have already quoted, states that the principal rock of Mount Harriet is a coarse yellowish-green or grey sandstone, apparently very absorbent of water; also that close to the top of the hill the sandstone appears in vertical beds, but that on the ascent the rocks are much obscured by humus.

During the alternations from gloom to sunshine which the moving clouds so frequently created, the effects of light and shade upon the extended landscape open to our view were exceedingly beautiful, and sometimes so wonderfully rapid and complete as to be almost startling. In a single instant it seemed as if the forest changed from a brilliant combination of vivid greens to a solemn and uniform, heavy-looking, almost blue tint, while perhaps, after the lapse of a few seconds, it would suddenly reveal itself again in all its former sunny brightness. The luminous play upon the water under these conditions, though perhaps not quite so striking, was even more lovely still,—now presenting to our gaze a sapphire sea, and anon passing quickly to chrysoprase and emerald, to flash back upon us next moment with an intensity of blue rivalling the deepest azure of a southern sky.

There were scarcely any flowers in bloom, excepting orchids, which seemed to be chiefly representatives of various species of *Dendrobium*, but they were all out of reach, and I did not procure a single specimen. Many of the trees were unknown to me, but in the forests I recognized a few that I was familiar with; amongst which were *Dipterocarpus lævis*, *Mesua ferrea*, and *Pterocarpus dalbergioides*. There was also a tree with brilliant and red decaying leaves, so like *Terminalia catappa*, that I have no doubt of its having been *T. procera*, as mentioned by Mr. Kurz;* an *Acacia* in tolerable abundance, and a *Lagerstræmia*; also in the lower and denser forest extending down to the beach, *Sterculia fœtida* and a gigantic *Dillenia*, which was probably *D. pilosa* of Roxburgh. I met with no tree-ferns of any kind, and scarcely any palms, excepting a prickly climbing *Calamus*, which was very common, while the great pendulous lichens, such as I have seen adorning the damp forests of the eastern Himalaya in profuse quantities, were altogether absent. *Pothos scandens*, however, another characteristic plant of the moist Himalayan woods, was everywhere plentiful and luxuriant. Mangroves

* J. A. S. B., xxxix. p. 231.

abound in some places, fringing the shore with their brilliant green foliage and growing upon them. One of my friends found large quantities of *Orchidaceæ*, chiefly species of *Dendrobium* and *Pholidota*.

Of birds, we obtained specimens of a beautiful parrakeet (*Palæornis nicobaricus*) which seemed very abundant, but generally kept well out of reach of shot in the upper branches of the great trees; of the peculiar-looking black woodpecker (*Muelleripicus Hodgii*), and some of the Indian green imperial pigeons (*Carpophaga sylvatica*). We saw also a good many bulbuls (*Otocompsa jocosa*) and sunbirds (*Nectarinia pectoralis*); a *Pericrocotus*, which was most probably *P. peregrinus;* and a few others which I failed to identify. A small collection, however, made by a brother officer on Mount Harriet, and in the forests stretching downwards to the sea-beach, furnished me with the following species:

Palæornis erythrogenys, Blyth; *Centropus andamanensis*, Tytler; *Macropygia rufipennis*, Blyth.; *Chalcophaps indicus*, Linn.; *Osmotreron chloroptera*, Blyth; *Pericrocotus peregrinus*, Linn.—*Pericrocotus flammeus*, Forster; *Loriculus vernalis*, Sparm.; *Irena puella*, Lath.; *Oriolus andamanensis*, Tytler; *Merops quinticolor*, Viell; *Myiagra Tytleri*, Beavan; *Alcedo asiatica*, Swains; *Todiramphus collaris*, Scop.; *Picus andamanensis*, Blyth; *Edolius malabaricus*, Scop.

After a most delighful sojourn of some hours on the summit of the hill, the lengthening shadows warned us to retrace our steps. But before we reached Ross Island the soft obscurity of evening was fast settling down over land and sea.

"Now nearly fled was sunset's light,
Leaving but so much of its beam
As gave to objects, late so bright
The colouring of a shadowy dream;
And there was still when day had set,
A flush that spoke him loth to die—
A last look of his glory yet,
Binding together earth and sky."

ON THE MOLLUSCA OF THE POST-PLIOCENE FORMATION IN ACADIA.

By G. F. Matthew.

[From the Annals of the Belgian Society of Malacology (Société Malacologique de Belgique, Tome IX, 1874.)]

As an introduction to the immediate subject of this paper it may not be out place to give a brief outline of the chief characteristics of the Post-Pliocene Formation in the North-eastern part of North America.

Two writers, eminent both in America and Europe, have given much time to the study of this formation. Dr. J. W. Dawson in his writings on this subject, published in this Journal, and in a synopsis entitled "Notes on the Post-Pliocene of Canada," Montreal, 1872, gave a full account of the beds and of the organic remains which they contain, in the Province of Quebec. Dr. A. S. Packard of Salem, Massachusetts, has also devoted much time to the study of Surface Geology, chiefly that of Labrador, and of the State of Maine ; and has published the result of his observations in the Memoirs of the Boston Society of Natural History, vol. I. part II.

While these authors have discussed the phenomena of the Post-Pliocene in the region to the west and north of Acadia, but little attention has been given to this country itself. My object in this paper is to supply this deficiency in part, by mentioning a few facts bearing on the distribution of the Mollusca which the Acadian beds contain ; both in relation to the depth of the sea in which they flourished, and their geographical range now, as compared with their distribution in Post-Pliocene times.

The history of this period in North-eastern North America opens with the movement of enormous masses of ice over the face of the country from north to south. At every point where the solid rocks are laid bare, deep and regular striæ or scorings attest the universality and great power of this attritive force. Dr. Dawson holds to the theory that these gr oves, and the "Boulder Clay" which lies at the base of the surface deposits, are due to the action of water-borne ice, carried southward by a strong polar current ; while Dr. Packard boldly advocates the view that the phenomena are due to the movement of a

continental glacier of vast thickness and weight, which descended southward across Canada and New England. So far as my own observations go, it seems to me quite impossible to explain all the phenomena of the Drift or Post-Pliocene period in Acadia upon either of these two theories taken alone : both glacier and iceberg have had free scope and course here, but to describe fully the results of their presence would swell these preliminary remarks to undue proportions. Suffice it to say that the period opened with the operation of that powerful agent—ice—which gave rise to the drift striæ, and the boulder-clay ; and that the marine life of the epoch was extremely scanty.*

The Boulder-clay is universally distributed in Acadia, being found near the tops of the highest hills and throughout the whole extent of the country. It is a deposit which so far as we know is without stratification, and consists of an intimate mixture of sand and clay, in which innumerable *striated* blocks and fragments of stone are imbedded : these stones have been transported southward, and the majority, in the southern part of New Brunswick, may be traced to ledges of old rock not more than ten or fifteen miles north of the places where they are now found.

Throughout a great part of the country the Boulder-clay is overlaid by another deposit which has been denominated " modified drift" from the fact that the materials of which it is made up are derived from the Boulder-clay and have been sorted and rearranged by water. It is well developed in the valley of the St. Lawrence River, where Dr. Dawson divides it into the Leda clay and Saxicava sand. A threefold division of the formation would be more appropriate in Acadia, for in this country the Leda clay is separated from the Boulder-clay by stratified sand and gravel beds, enclosing *smoothed* boulders : in its lower part this arenaceous group has irregular beds of Boulder-clay alternating with the sandy strata ; but the mass of it is distinguished from the typical Boulder-clay, by the absence of clay, the roundness and smoothness of the stones, and the well marked stratification. No trace of organic remains has yet been found in this group, and the arrangement of the beds in many places is such as to indicate that they were deposited in waters of considerable

* Dr. Dawson affirms the presence of *Portlandia glacialis* in true " Till" or Boulder Clay on Murray Bay River in the Valley of the St. Lawrence.

depth traversed by a powerful ocean current. It would appear, therefore, that when these beds were deposited the Acadian region was submerged, and that a resistless current from the icy regions of the Pole flowed over it, sweeping the finer parts of the Boulder-clay from the exposed hills and ridges to more profound depths in the ocean, and heaping up the coarser materials into "horsebacks" (escars) "moraine ridges" and mounds, depending for their direction and form upon the position of submerged elevations along the sea-bottom. Similar conditions now prevail in certain parts of the North Atlantic Ocean, where there are wide tracts of the ocean floor covered with sand, having scattered stones and boulders, and which in like manner are swept by strong currents flowing from the Polar regions.

I would suggest for these Acadian beds the name *Syrtensian*, as indicating their composition and the conditions under which they were formed. Dr. Packard has used the same term in a different sense; viz: as a name for the *fauna* of a sub-arctic type which characterizes the fishing banks off the coast of New England.

Beds of the kind I have described above would appear to underlie the Leda clay in the broad plain of the St. Lawrence; for in Dr. Dawson's section of the modified drift at the Glen brick-works near Montreal, he gives a thickness of twenty feet of such beds beneath the Leda clay at that place. A similar sub-stratum to the Leda clay is to be found along the Atlantic coast of the United States as far south as Massachusetts Bay, as appears from the figured sections and text of Dr. Packard's memoir; and it is clear from the writings of Prof. C. H. Hitchcock and others, that this part of the Post-Pliocene is similarly constituted as far south as Long Island Sound.

The Syrtensian beds of Acadia graduate upward into Leda clay when the latter is present. This group consists of finely laminated clay beds with thin partings of sand, near the coast; but among the hills of the interior it is chiefly made up of sand and clay in alternate layers, and in nearly equal proportions. In certain limited tracts away from the coast the group contains only sand beds. Among the hills of the interior, organic remains are but seldom met with in the Leda clay, but on the lower levels near the coast a variety of fossils have been exposed by the wearing of the clay banks along the shores of the Bay of Fundy, and in cuttings along lines of railway. Among these

may be mentioned bones of a seal and a whale, teeth of a large mammal, various crustaceans, echinoids, worms, corals and sea weeds, besides the molluscs which it is my purpose now to describe.

In the following list I have noted the bathymetric and geographical range of most of the species named, and added further remarks upon any peculiarities which seemed worthy of mention. The zones of depth referred to in this catalogue are *Littoral*—the space between high and low water marks; *Laminarian*—from low water to a depth of fifteen fathoms; *Coralline*—the depth from fifteen to fifty fathoms. For the vertical range of species given in this paper I am in most cases indebted to Dr. Stimpson's catalogue, "Shells of New England." The Bay Chaleur shells were collected by Mr. Robt. Chalmers.

The localities indicated by letters are—R. C., River Charlo, B. P., Black Point, R. B., River Benjamin, T. R., Tatagouche River—all on Bay Chaleur; St. A., St. Andrews and Oak Bay, St. G., St. George, St. J., St. John, in the Bay of Fundy.

Neptunea tornata, Gould.—Recent, Arctic seas to the Gulf of St. Lawrence.—Fossil R. C., R. B., St. A. Not common either in the Bay Chaleur or Bay of Fundy deposits. Another species of this genus *N. decemcostata*, which though now living on the coast has a more southerly range than *N. tornata*, has not been found in the Leda clay further north than Brunswick, Maine.

Sipho Kroyeri, Möller.—Recent, Arctic seas to Gulf of St. Lawrence.—Fossil, R. C., B. P., St. A.? Rare in these places.

Buccinum undatum, Linn.—Recent, Greenland to Massachusetts Bay.—Laminarian to Coralline.—Fossil, R.C., R. B., St. J., St. A. In the deposits on the Bay of Fundy this species is much more common than the succeeding *buccina*; but on Bay Chaleur shells of the other species are equally numerous.

B. tenue, Gray.—Recent, Arctic seas to the Gulf of St. Lawrence.—Fossil, B. P., R. C., St. J. Much less abundant than *B. undatum*.

B. glaciale, Linn.—Recent, Greenland to Gulf of St. Lawrence.—Fossil, B. P. Rather scarce.

B. Gröenlandicum, Chemn?—Recent, Greenland.—Fossil, T. R. I am not sure that this species is correctly referred, the specimen (sent to me by Rev. C. H. Paisley) is more ventricose than that figured by Dr. Dawson; the upper part of the whorls is also less tumid.

B. Donovani, Gray.—Recent, Newfoundland and northern seas. —Fossil, B. P. Rare. A single shell with the characteristic ridge on the lower whorl.

Lacuna neritoidea, Gould.—Recent, Nova Scotia to Long Island Sound.—Littoral to Laminarian.—Fossil St. J. Rare. I mention this species on the authority of Dr. A. S. Packard.

Lunatia heros, Say.—Recent, Labrador to Long Island Sound, but scarce to the South of Cape Cod—Littoral.—Fossil, R. C. Two small insymmetrical individuals shewing the result of dwarfing like a shell of the same species collected at Quebec by Dr. Dawson.

L. heros, Say ? var. *Chalmersi*. A specimen from Benjamin River received from Mr. Chalmers. If of the species *L. heros*, it is a strongly marked variety. It is proportionately much higher than the typical form ; the whorls are more tumid, and the spire more elevated ; the lower part of the pillar lip, which in *L. heros* is thin below the umbilical opening, is in this specimen thickened and rounded ; the umbilical opening is smaller than in Say's shell, and there is a strong ridge on the upper margin of the last whorl, next the suture. The length of the spire in specimens of *L. heros* collected in the Bay of Fundy, when compared with that of the aperture is as 1 to $4\frac{1}{2}$ or 5 ; but in some from Mingen River on the south coast of Labrador the proportion is 1 to $3\frac{2}{3}$: and as the ratio in Mr. Chalmers shell is 1 to $2\frac{1}{3}$ it is probably a high northern variety of this species. Length $1\frac{5}{8}$ inch, breadth $1\frac{1}{4}$ inch.

Natica affinis, Gmelin (*clausa* B. & Sow.)—Recent, Greenland to Massachusett's Bay.—Corralline zone.—Fossil, R. C., R. B., T. R., St. J., St. A. Common in Bay of Fundy deposits, but more plentiful in those of Bay Chaleur.

Bela turricula, Montagu.—Recent, Gulf of St. Lawrence to Massachusett's Bay.—Coralline.—Fossil, R. C., B. P. Rather small and not common.

Bela harpularia, Couthouy.—Recent, range as in the last species.—Laminarian to Coralline.—Fossil, same localities as last. Infrequent.

Pecten Islandicus, Chemnitz.—Recent, Greenland to Long Island Sound.—Laminarian to Deep Sea Coralline.—Fossil, St. John. Plentiful at one locality.

Pecten tenuicostus, Mighels, (*Magellanicus*, Lam.)—Recent, Labrador to Massachusett's Bay.—Laminarian to Coralline.—Fossil, St. John. Rare.

Pecten tenuicostatus var. ? A shell resembling this species in form and sculpture occurs at St. John. It is thicker than the ordinary form of the species and has fainter striæ.

Yoldia sapotilla, Gould.—Recent, Labrador to Long Island Sound.—Coralline—Fossil, a single valve at Black Point. This is not the variety of *Y. limatula* Say, reported by Dr. Dawson from the clays of Rivière du Loup, for it agrees in all respects with *Y. sapotilla*, and has hinge teeth which are excavated on their outer side.

Portlandia glacialis, Gray (*Leda truncata*, Brown).—Recent, Arctic seas.—Fossil, R. C., R. B., T. R., St. J., St. A. This is the most abundant shell in the great mass of the Leda clay along the shores of the Bay of Fundy, but is infrequent in the deposits on the south side of Bay Chaleur. The abundance of this shell in the clays of the St. Lawrence Valley led Dr. Dawson to denominate those beds "Leda clay." *P. glacialis* becomes dwarfed and scarce where the deposit called the Leda clay is sandy.

Leda minuta, Fabricius.—Recent, Greenland to Nova Scotia —Coralline.—Fossil, B. P. and St. J. Rare. Our specimens are shorter and more pouched than those collected at Rivière du Loup by Dr. Dawson. The shells from Bay Chaleur are of the variety *complanata*.

Leda pernula, Muller.—Recent, Arctic seas to Long Island Sound—Coralline.—Fossil, R. C., B. P., T. R., St. G., St. A. —The varieties *tenuisulcata* and *buccata* are common at the localities on Bay Chaleur; but both there and on the Bay of Fundy the former is the more common shell; while in specimens from Rivière du Loup var. *buccata* prevails.

Nucula tenuis, Montagu.—Recent, Greenland to Casco Bay, Maine.—Coralline.—Fossil, common on Bay Chaleur at the localities named. Not yet found on the Bay of Fundy.

Nucula expansa, Reeve.—Recent, Arctic seas to the Gulf of St. Lawrence. Common at St. John with *Portlandia glacialis*, and occurs at St. George and St. Andrews. Only one valve from Bay Chaleur (Jacquet R.)

Modiolaria discors, Linn.?—Recent, Labrador to Massachusett's Bay.—Laminarian.—Fossil at Black Point, one valve; too imperfect to determine the species but resembles this one in form.

Mytilus edulis, Linn.—Recent, Greenland to Long Island Sound —Littoral.—Fossil, R. C., R. B., St. J., St. A. Common in upper beds of the Leda clay at St. John ; and is plentiful on Bay Chaleur where var. *elegans* is common.

Cryptodon——sp. ?—Fossil St. John. Rare. Specimens of a Cryptodon quite different from *C. Gouldii*, Phil., are to be found occasionally in the starfish beds of Duck Cove : it is near *C. flexuosus* of the British seas, but differs in being more tumid, especially toward the beaks, and these are more sharply curved at the points than those of the British species named. The furrow extending from the beak toward the posterior margin of our shell is much narrower than in *C. flexuosus ;* and the ridge dividing it from the ligamental border is correspondingly narrowed and sharpened. There is a faint ridge descending from the beak to the base of the anterior border, and between it and the lunule, the concentric wrinkles of the epidermis are stronger. Shell thin and fragile. Epidermis pale yellowish brown.

Kellia suborbicularis, Montagu.—Recent, N. Europe, (Nova Scotia and Massachusett's Bay, Gould.) Fossil at Black Point. Rare. A small shell, which agrees with the figure and description of this species in Gould's Invertebrata of Massachusetts.

Serripes Gröenlandica, Chemnitz.—Recent, Greenland to Massachusett's Bay.—Coralline.—Fossil R. C., R. B., T. R., St. J., St. A. Recent individuals from Mingen River, Labrador, are double the size of our largest shells from the Post-Pliocene. Shells from the clays of the Bay of Fundy are thin and fragile.

Cardium pinnulatum, Conrad.—Recent, Gulf of St. Lawrence to Long Island Sound.—Laminarian.—Fossil, St. J., St. G. Rather plentiful in a few places. These shells, especially the larger ones, are more angulated than the recent individuals from Massachusett's Bay figured by Dr. Gould.

Astarte arctica, Möller, var. *lactea ?*—Recent, Greenland to Casco Bay, Maine.—Fossil at St. Andrews where it is infrequent. This is the largest of our Astartes ; it is wider than *A. semisulcata*, Gray, and possesses a beak which is nearer the anterior margin and more acute.

Astarte compressa, Linn.—Recent, Greenland to Labrador.—Fossil at St. Andrews. Infrequent. This is intermediate in form between the last and the following species ; it is a deeper, higher and thinner shell than *A. lactea*.

Astarte Banksii, Leach.—Recent, Greenland to Nova Scotia. —Fossil at St. John. This species has more prominent beaks than the last, and the anterior border is arched inward more deeply at the lunule.

Spisula solidissima, Chemnitz ? var. *Acadica*.* Recent, Labrador to Long Island Sound.—Littoral to Laminarian.— This form is from the higher clay beds at St. John ; and in ponderosity, form of the cartilage pit, position of the beaks, and shortness of the lateral teeth, approaches the European *S. solida*. It may be an arctic variety of *S. solidissima*. Height $1\frac{3}{8}$, length $1\frac{5}{8}$.

Macoma fusca, Say, var. *Gröenlandica*.—Recent, Greenland to the Bay of Fundy.—Littoral, the variety Laminarian (to Coralline ?) Fossil, R. C., B. P., T. R., St. J., St. A. A small rough variety abounds at Lawlor's Lake near St. John, in a bed which appears to belong to the Saxicava sand, but a larger and smoother form is the most abundant at Bay Chaleur; the latter recalls *M. solidula* of Europe, but is distinct. *M. Gröenlandica* still lives in the deeper waters of the Bay of Fundy, and in the sand-flats along its shores *M. fusca* abounds.

Macoma calcaria, Chemnitz.—Recent, Greenland to the Bay of Fundy.—Coralline.—Fossil, same localities as the last species, but while that (on the Bay of Fundy at least) is confined to the Saxicava sand and upper part of the Leda clay, this one ranges through the whole of the latter deposit.

Pandora (Kennerlia) glacialis, Leach.—Recent, Arctic seas to the Gulf of St. Lawrence.—Fossil at St. John. Frequent in the starfish beds at Duck Cove. It was first referred to *P. trilineata*, Say., from which Dr. Dawson says it is quite distinct.

Lyonsia arenosa, Möller.—Recent, Greenland to Nova Scotia. —Fossil with the last species.

Lyonsia Norvegica ?—Recent, Arctic seas.—Fossil with the last two species, and more common than *Pandora glacialis*. From *Lyonsia hyalina*, Conrad., this shell differs in being more ventricose, somewhat higher, and in having no radiating furrows, though in some individuals there are obscure radiating lines. I have not seen *P. Norvegica* and therefore am not sure of the identity of our shell with it.

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* N.B. I find that this shell agrees very closely with specimens of *S. truncata*, Mont. received from England, and differs chiefly in the shortness of the lateral teeth and in having a more oval outline. It may be an exotic.

Mya truncata, Linn., and variety *Uddevallensis*.—Recent. Greenland to Massachusett's Bay.— Littoral to Coralline.— Fossil, R. C., B. P., St. J., St. A. Frequent. The long form occurs in the clays at St. John, but the variety is more prevalent.

Mya arenaria, Linn. and var. *acuta*.—Recent, Greenland to Long Island Sound.—Littoral.—Fossil, R.C., B.P., T. R., St.J., St. A. I have found this species only in the Saxicava sand. It is now one of the most abundant molluscs on our coast. The variety which is probably Say's *Mya acuta*, is distinguished by being markedly ovate in form : it is inflated and expanded in front, and the posterior slope from the hinge is much straighter than in the typical form. The variety is by far the most abundant shell in the Bay Chaleur clays, but the Myas of the St. John beds are of the ordinary form. It may therefore be conjectured that the var. *acuta* is of northern origin.

Saxicava rugosa, Linn., and var. *arctica*.—Recent, Greenland to Long Island Sound.—Littoral to Coralline.—Fossil, R.C., B. P., T. R., St. J., St. A. This very variable species is more abundant in the deposits of the St. Lawrence Valley and Bay Chaleur, than in those of the Bay of Fundy. In going south from the St. Lawrence R. the more regular forms, such as *S. rugosa* and *S. pholadis*, increase in number, and the distorted varieties *S. arctica*, *S. rhomboides* and *S. hiatella* decrease. For instance in a collection made at Rivière du Loup, for which I am indebted to Dr. Dawson, I find all but two are distorted forms; in Mr. Chalmer's collection from Bay Chaleur the irregular ones still predominate, and two-thirds of the shells would fall into the varieties *arctica*, &c.; but in the shells collected from the Bay of Fundy clays, this proportion of distorted to regular forms is reversed ; at St. Andrews one third only are of arctic types ; and of those collected at St. John, only one-fifth. In the specimens of this species sent to me by Dr. Packard from Brunswick, Maine, all the shells are regular, but one has the beak at the anterior fourth of the valve.

Lepralia hyalina, Johnston, Leda clay, St. John.

Membranopora pilosa, Johnston, Leda clay, St. John.

Cellepora pumicosa, Ellis, Leda clay, St. John.

In this list there are more than thirty species of mollusca, a number large enough to enable us to draw inferences, imperfect

though they may be, regarding the depth of the sea in which these creatures lived. As I have not visited the Bay Chaleur and am not informed of the exact horizon in the Post-Pliocene deposit of that district, from which the shells recorded in the above catalogue were taken, I am unable to say whether there is a regular gradation from deep water forms in the lower beds to littoral species in the higher, as in the Bay or Fundy, or not: and it will be possible to speak only in general terms of their bearing on the question of the depth and temperature of the sea on the northern confines of Acadia during Post Pliocene time. In the clay-beds of the Bay of Fundy with which I am more familiar, there are proofs of a progressive shoaling of the ocean along this coast during the period named. The lowest beds are a compact clay, which is either red or grey, according as it is derived from the red rocks of the Carboniferous area, or the grey slates, &c., of the region west of it. This compact clay contains very few organic remains, and these are chiefly shells of *Portlandia glacialis*. At St.John it graduates into fine dark colored clay which varies in tint from dark grey and liver-brown nearly to black, according to the amount of organic matter disseminated through it; and here the shells of *Portlandia glacialis* abound. This portion of the clay contains beds of black sand from one to three inches thick, holding *Ophioglypha Sarsii*, *Pandora glacialis*, *Lyonsia Norvegica?* *L. arenosa*, *Cryptodon* sp. ? and other shells, none of which indicate a less depth of water than that of the Coralline zone. These dark beds are in turn overlaid by other red clays which differ from the lower red clays in being of a browner hue and having numerous intercalated beds of brown or grey sand; these clay beds while they contain *Balanus crenatus*, *Portlandia glacialis*, *Nucula expansa*, &c. of the lower horizon, have in addition such species as *Buccinum undatum*, *B. tenue*, *Mya truncata*, *Macoma calcaria*, *Saxicava rugosa*. A somewhat shallower sea is indicated by the occurrence, at St. John, of clay beds holding *Mytilus edulis* and *Cardium pinnulatum:* while a still further withdrawal of the ocean is shown by the contents of the sand beds which cover these clays; these appear to be the equivalent of the Saxicava sand for they contain shells of *Mya arenaria* and *Macoma fusca*.

While the change from deep-water forms to those of the immediate sea-shore, gives clear proof of the progressive shoaling of the Post-Pliocene sea in this region, it does not show whether

this change was a gradual one, or was brought about by sudden and repeated elevations of the land. The mode by which the shoaling of the Post-Pliocene sea was effected is explained, however, by the existence of terraces at several levels on the land near the coast. The change of level was, it would seem, accompanied by rapid elevations, separated by intervals of rest, and the amount of these periodic changes of level can (with certain allowances for the peculiar tidal phenomena of the Bay of Fundy) be estimated with an approach to accuracy. Any indentation of the shore line along the coast where sediment could accumulate subject to the wash of the waves, would have sand flats extending to the lowest limit of tide, and in the Bay of Fundy, where the rise and fall of the tides is very great, such flats would have a slope seaward of twenty or thirty feet: if such a plain were lifted above the sea level and terraced by the action of the waves, the resulting terrace would vary between the limits indicated. This is found to be the case near St. John, where the first terrace rises to the height of fifteen feet above the sea. The next, which is much more conspicuous, varies from forty to sixty feet; and can be seen to be composed of the three subdivisions of the modified drift; viz. Syrtensian beds, Leda clay and Saxicava sand. A third terrace begins at the height of about 100 feet and extends to 120 feet. The surface layers on this terrace are coarser than those of the last and consist of stratified gravel and sand. Another terrace of similar material was observed at a height of 150 feet, and a fifth at 300 feet. Terraces at this height are very gravelly, quite irregular, and cannot always be distinguished from Syrtensian ridges. As those ancient sea-borders are a memento of the rise of the land in Post-Pliocene times, so the composition of the Leda clay in the Southern Highlands of New Brunswick, furnishes a criterion whereby one can judge of the depth of the sea during the whole period occupied in its deposition. In these hills many of the valleys are cut down nearly or quite to the sea level; and while they are partly filled with modified drift, the neighboring hills are covered to a greater or less degree with Boulder-clay. Leda clay forms a notable part of the modified drift in these valleys, and rises up on their slopes to a height of 200 feet or more. Very instructive sections of these deposits on the east-side of the Nerepis and Douglas valleys in Queen's County were made in grading the track of the E. and N. A. Railway: here, where

several small streams come off the hills on the western side of the valley, the whole thickness of the "Leda clay," where these streams cross the railway track, presents a succession of *sand beds;* but in tracing these beds in the cuttings along the track of the Railway north or south from the channels of the brooks the sand becomes more and more interlaminated with clayey layer until at length the deposit resumes its normal aspect. It thus appears that when the Leda clay of these valleys was laid down, the tops of the neighboring hills were above water, and as the current from the brooks was sufficient to drive off all the muddy sediment in the waters of the Leda clay sea, at their mouths, the depth of the sea above its present level could not have greatly exceeded 200 feet.* The structure and composition of the beds laid down at this period among the southern hills corroborates the result of an examination of the vertical range in the species of shells which the corresponding deposit at the coast contains.

Another fact revealed by the examination of these fossils which bears upon the probable depth of the Leda-clay sea is the indication given by the localities of the fossils enumerated in the preceeding list, of a geographical division into two groups, in one of which the species have a more arctic range than the other. Thus on the Bay Chaleur a number of arctic *Buccina* occur of which only one, *B. tenue*, has been recognised in the Bay of Fundy; and while *Nucula tenuis* abounds at Bay Chaleur it has not been found in the clays of the Bay of Fundy, where its place is supplied by *N. expansa*. On the other hand several species of the present Acadian marine fauna, such as *Lacuna neritoidea*, *Cardium pinnulatum*, and *Pecten tenuicostatus* occur in the Post-Pliocene of the Bay of Fundy, but have not been found in a fossil state on the Bay Chaleur, though now they are plentiful in its waters. This marked contrast in the grouping of the Post-Pliocene shells of these two bays, cannot be accounted for by differences of latitude alone, but seems rather to have been caused by the existence of a barrier to the free intermingling of the waters of the Bay of Fundy with those of the Gulf of St. Lawrence—a barrier such as would still exist were the intervening country depressed to a depth not exceeding one hundred and fifty, or two hundred feet.

* I have other facts bearing upon this point which will be presented in a future article.

These considerations relate chiefly to the depth of the sea in which the more highly fossiliferous part of the Leda clay was deposited, but other considerations indicate that the higher parts of the Leda clay were formed in shallower waters. I have mentioned on a preceding page that the dark colored clays abounding with organic matter, and containing shells which indicate the depth of water above named, are overlaid at St. John by reddish clay with sandy layers. Just above the "Falls" of the St. John River in Fairville these upper clays may be seen to rest upon eroded beds of dark clay, and at other points they rest directly upon the tough red clays. This group of beds, which contains fossil shells of the Laminarian zone, appears to have been laid down when the land had risen to within one hundred feet of its present level, and may be denominated the Upper Leda clay. It, together with all the older portion of the clay deposit, suffered denudation preparatory to the deposition of the Saxicava sand, a group consisting of grey, buff and brown sand, occasionally capped or underlaid by gravel beds; and which from the occurrence in it of littoral species only may be regarded as a tidal deposit.

[To bring all the known facts relative to the Post-Pliocene deposits in this region into harmony, it appears necessary to assume that at the beginning of this age, Acadia and the neighboring portions of the American continent were elevated to a height of several thousand feet above the sea, and that the extensive plateau thus formed was bordered on the south by deep oceanic waters. Such a change in the relations of sea and land (accompanied perhaps by similar movements under other meridians in the Northern Hemisphere) would lead to the formation of a *glacier zone* across New England and Canada, facing a sea open to the influx of heated waters from the equatorial regions. As glaciers formed in this way would receive accessions to their mass on the southern side only, they would bear with immense weight upon the coast line, and (supposing that the earth's crust possesses a certain amount of plasticity) would have a tendency to depress it beneath the sea, causing at the same time a corresponding elevation of the interior region. As the coast-line sank from this cause, the *glacier-zone* would gradually travel northward, seeking the rising land, and in the deep waters in front of its southern margin, mud and stones swept off the land by the moving ice, would be deposited. Such a deposit would resemble

the Boulder-clay, and might contain the remains of a few organisms capable of withstanding the extreme temperature of an icy sea. The neighboring land would for a time protect this deposit from the action of arctic currents, but as the gradual retrocession of the coastline to the north continued, the polar current would begin to act upon the sea-bottom, and sweep off the finer materials to greater depths in the ocean : deposits formed under these circumstances would resemble the Syrtensian beds.

From the recession of the glacier zone to the north a further result would follow : the land relieved from the pressure would rise again ; submerged ridges would come near the surface of the ocean and shut off the polar current ; and in the quiet seas and shallow, sheltered sounds and bays thus made, deposition of fine sediment like the Leda clay would proceed. As a final step in the process of re-elevation the sea bottom would reach the tide level, and sand banks and flats of material like those of the Saxicava sand would be formed.]

Following this interpretation of the phenomena of the Post-Pliocene period in Acadia (especially for the Bay of Fundy shores) the history of its marine life would be in brief as follows :

Original Drift.

Boulder-clay.—Depression of the present land beneath the ocean about 2000 to 1000 feet—Life meagre and entirly of arctic forms.

Modified Drift.

Syrtensian beds.—Depression about 1000 to 500 feet. Present coast line in the Deep-sea-coralline zone. Life probably sparce. Strong ocean currents.

Lower Leda Clay.—Depression for the tough (lower) clay 500 to 200 feet : for the dark (upper) clay 100 to 200 feet. Present coast line in the Coralline zone. Life in the older beds a few deep water species ; in the newer an abundance of marine life.

Upper Leda Clay.—Depression 100 to 60 feet. Present coast line in the Laminarian zone. Life, fossils less abundant than in the last ; the waters subject to greater disturbance.

Saxicava Sand.—Depression 40 (or less) to 60 feet. Present coast line in the Littoral zone. Life, molluscs all of shore-loving species.

REPORT ON THE GEOLOGY AND RESOURCES OF THE REGION IN THE VICINITY OF THE FORTY-NINTH PARALLEL, FROM THE LAKE OF THE WOODS TO THE ROCKY MOUNTAINS. By GEORGE MERCER DAWSON, Assoc. R.S.M., F.G.S., Geologist and Botanist to the Commission; addressed to Major D. R. CAMERON, R. A., Commissioner. Large 8vo., pp. 379, with numerous maps and illustrations.

In this volume Mr. Dawson has given us in a very clear and thorough manner the result of his explorations while acting in the capacity of geologist and botanist to the Boundary Commission. We have not space in this number for lengthy extracts, but the following from the prefatory note addressed by Mr. Dawson to the Commissioner will serve to give an idea of the character and scope of the work:—

"In undertaking single-handed the care of Natural History work in connection with the Boundary Commission, it was obvious that in attempting too much it might happen that nothing should be well done. I therefore decided to give the first place to geology; and in that field to endeavour to work out as far as possible the structure of the country, and to make illustrative collections of rocks and fossils, rather than to amass large local collections at the expense of general information. Such time as could be spared from the geological investigations has been devoted to collection and work in other departments; and in this Report the results are presented, elaborated in so far as the time at my disposal would allow, and supplemented also by several valuable notices of the collections in special departments, by gentlemen whose names are elsewhere stated.

"The field work, in extent, has directly covered a region, stretching from the Lake of the Woods, on the east, to the Rocky Mountains on the west, and lying in the vicinity of the forty-ninth parallel, which here forms the International Boundary. In time it has extended over two seasons, those of 1873-74. Owing to the vastness of the region covered by the operations of the survey, much of the period actually spent in the field has been necessarily employed in more or less arduous, and often almost continuous travel. * * * * * *

"The main geological result arrived at is the examination and description of a section over 800 miles in length across the central region of the continent, on a parallel of latitude which has heretofore been geologically touched upon at a few points only, and in the vicinity of which a space of over 300 miles in longitude has—till the operations of the present expedition—remained even geographically unknown.

"In working up the geological material, I have found it necessary to make myself familiar with the geological literature, not only of the interior region of British America, but with that of the western portion of the United States to the south, where extensive and accurate geological surveys have been carried on. It has been my aim to make the region near the boundary line as much as possible a link of connection between the more or less isolated previous surveys, and to collect by quotation or reference, the facts bearing on it from either side. In this way it has been attempted to make the forty-ninth parallel a geological base-line with which future investigations may be connected. The matter contained in the special preliminary report on the Lignite Tertiary formation, published last year, has in this final report been included, in so far as necessary to complete the general section on the line."

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NOTES ON THE LOCUST INVASION OF 1874 IN MANITOBA AND THE NORTH WEST TERRITORIES.

By George M. Dawson, Assoc. R. S. M., F. G. S.

The ravages of the western locust, or devastating grasshopper, have of late years been very great, over all the eastern fertile region of the plains, and the insect has forced itself on the attention not only of the farmer, who directly bears the loss, but also on that of all interested in the western spread of settlement and civilization: liability to its inroads constitutes in fact, at the present time, the greatest difficulty in the way of the rapid occupation of a vast tract of otherwise desirable country.

While a member of the British North American Boundary Commission, I had the opportunity of passing over a great part of the region subject to the ravages of the locust; and it was intended to include in my first report as complete an account of the locust raid of 1874 as I could compile. For several reasons, however, this proved impracticable. Though by circulars, with a list of specific questions, issued for the purpose, much information was obtained from various parts of British North America, and the Western States, much of it was of a somewhat indefinite character. Mr. C. V. Riley, Entomologist to the State of Missouri, has also since published a pretty full account of the invasion in so far as the Western States of the

Union are concerned, in his Seventh Annual Report, to which my information could only enable me to add a few particulars. I therefore present here in a summary form the facts collected from the region lying north of the forty-ninth parallel, as a contribution to the history of the invasion of the summer of 1874, and a slight addition to the general knowledge of the locust and its migrations.

My thanks are due to the gentlemen who have kindly answered the questions addressed to them, and especially to those who have furnished me in addition with general results of their experience.

It now seems certain that the locusts causing such widespread damage on the western plains, belong to a single species, known to entomologists by the name of *Caloptenus spretus*. For its description, Prof. Thomas' Synopsis of the Acrididæ, or Mr. Riley's report above mentioned, may be referred to. The locust is a native of the high and dry western portion of the interior plain, and not of the alpine vallies of the Rocky Mountains, as at one time supposed. North of the forty-ninth parallel, the whole area of the third, or highest prairie-plateau, and probably much of the second, are congenial breeding places, and here the locusts are always in greater or less numbers, but in certain seasons they sweep eastward and southward in immense hordes, reaching to, and even beyond the limits of the region of prairie. In range, the insect is not bounded westward by the Rocky Mountains, save where they coincide with the eastern unbroken front of the western forest region, as in British America. They extend southward at times to the Raton Mountains, and into Texas, while to the east they have spread to the prairie country of the Mississippi, and on more than one occasion have penetrated far into Iowa. Northward, they appear to be limited by the margin of the coniferous forest which opportunely follows the line of the North Saskatchewan River.

It is difficult to ascertain exactly what the causes are which lead, or drive the locust in certain years to leave its western habitat, though it is possible that simply an excessive increase in numbers may bring about that result. Only a mere fraction of the vast multitude of eggs deposited can under ordinary circumstances come to maturity, and their vitality and the survival of the young insects, may depend on so many circumstances, climatic and otherwise, that even on the above simple supposi-

tion a broad margin of uncertainty appears. It is probable, however, that the great locust invasions are the resultants of the actions of many agents, favorable or otherwise, all which it is highly desirable should be known as a preliminary to methodical and carefully devised efforts towards amelioration.

The spring and summer of 1874 in the northern part of the interior region were unusually dry, A dry climate is generally supposed to be favourable to the locust, and chiefly to the greater dampness of the eastern cultivated region is attributed the deterioration in vitality of the insects produced in a following year from eggs laid by an invading swarm. It is also noticed that in the eastern region the insect seldom survives to a third year. Over the western breeding-grounds, therefore, a dry and temperate spring may enable great numbers to come to maturity; while the continuance of the drought, combined with the unusual abundance of locusts, may tend to bring about wholesale emigration.

The locust has, however, many specific enemies, of which Mr. Riley catalogues four. *Trombidium sericium* and *Astoma gryllaria* are mites and external parasites; *Tachina anonyma* and *Sarcophaga carnaria*, flies, the larvæ of which feed on the grasshopper and live within it. All these, or at least representatives of both classes, appeared with the locust swarms in Manitoba in 1874, and the insects of some swarms appear to have been weak and sickly from the number of parasites clinging to them; circumstances lessening to a considerable degree the damage done by the insects, and the vitality of their eggs. The quantity of locusts destroyed by birds, especially while the insects are quite young, must be very great, and it has even been suggested that the rapid succession of invasions during the last few years may be due to the destruction of game birds, especially the prairie chicken. It would hardly seem, however, that this is by itself sufficient cause, though it may be one among the many.

The position of Manitoba near the north-eastern limit of the range of the locust, is in so far favourable, as it is only exposed to invasions from directions included between west and south, and the prevailing winds being north-westerly and coinciding with the direction of the migration instinct of the insect, carry the greater number of the swarms from their breeding places to the South-Western States. The northern situation of

the province also tends to exempt it from a double visitation, first from southern, and then from northern and north-western broods. This Mr. G. M. Dodge shows, has occurred in Nebraska, southern swarms arriving as early as May and June, and others in July and August. The number of grasshoppers borne to Manitoba is, however, more than sufficient, and in the neighbouring State of Minnesota, according to Mr. Solberg, the grain destroyed in 1874 by the insects is estimated at over 5,000,000 bushels!

The years in which the locust has appeared in Manitoba in great numbers, are as follows, as far as I have been able to learn: —In 1818, six years after the foundation of Lord Selkirk's colony, they arrived on the wing in the last week of July, and destroyed nearly all crops except wheat, which being almost ripe partly escaped. Eggs were deposited, and in the following spring wheat and all other crops were destroyed as fast as they appeared above ground. In 1819 eggs seem again to have been deposited,* and in 1820 the crops are said once more to have suffered greatly. The next recorded incursion is that of 1857, from which it would seem that for 36 years the insect had not appeared, or at least not in numbers sufficient to attract attention. In 1857 the crops are said to have been so far advanced as to escape great damage, but eggs were left, and in 1858 all the young grain was devoured. We do not now hear of them for five years, but in 1864 they again appeared, but neither the adults nor the young of 1865 were sufficiently numerous or widespread to do much injury. They did not visit the province in 1866; and in 1867, though numerous swarms poured in, they arrived late in summer, and did little damage, showing a practical exemption for nine years, or since 1858. In 1868, however, the young brood devoured everything, causing a famine. They left Portage La Prairie in a southerly direction. Foreign swarms again arrived in 1869, but too late for the crops, which were very bountiful. The young in 1870 did much harm, but were, I am told, chiefly confined to the vicinity of the Red River, not extending up the Assineboine as far as Portage La Prairie. In 1872, fresh swarms arrived, but as usual too late to do much damage to wheat. Eggs were, however, left in abundance in the northern part of the province, and about Winnipeg and Stone Fort the farmers did not sow in 1873. The young grasshoppers were migrating southward up the Red

* Hon. Mr. Gunn states from fresh swarms in August.

River Valley before their wings were fully developed. In 1874, winged swarms again came in from the west, leaving an abundant deposit of eggs over all parts of the province.

The records thus include, for this area, a period of fifty-eight years, and during that time locusts may be stated to have appeared either on the wing from abroad, or directly from the egg, in numbers sufficient to attract attention, in fifteen seasons, but caused wide-spread and serious destruction of crops in ten years only. The record shows an exceptional and alarming increase in the frequency of invasion of late years, an increase which has also been noticed in the Western States, and which though no doubt partly due to the fact that larger tracts have come under cultivation and consequent observation, apparently leaves a balance in favour of some real cause of increase; and this it should be the object of every one interested in the matter, to ascertain if possible.

In 1874, in British America, it would seem that no locusts were produced from the egg east of the 103rd meridian, and perhaps not east of the 104th, though southwards, in Dakota, some are said to have hatched near Minnie Wakan Lake, long. 99°, and the young insects also appeared in several localities on the Missouri River, near long. 101° lat. 47°. From various places included between the 104th and 111th meridians, and the 49th and 53rd parallels of latitude, the insects are known to have been produced in large numbers; and from the outcoming direction of swarms, and other facts, it may be safely concluded that eggs were hatched in many places over this great uninhabited tract. The young locusts do not seem to cover uninterruptedly any great area, but to occur in extensive patches here and there, where flights of the preceding season have rested. Nor do the separate swarms arrive at maturity at exactly the same time, though a sudden change in the weather, and more especially of the wind, may cause a nearly simultaneous departure of broods from a large tract. In 1874, in the area in question, movement appears to have begun late in June, and continued during July; the direction of flight where it has been recorded, lying between east and south. On July 12th, I observed swarms ready for flight on the high plains near White Mud River (long. 107° 35′ lat. 49°.) The day was hot and calm, and though many of the insects were on the wing at all altitudes, they were following no determinate direction, but sailing in circles and crossing each

other in flight. The greater number were hovering over the swamps or spots of luxuriant grass, or resting on the prairie. A slight breath of wind would induce them all to take to wing, causing a noise like that of the distant sound of surf, or a gentle breeze among pine trees. They appeared ill at ease, and anxiously awaiting a favourable wind.

These eastern and northern hordes were those which afterwards fell on Manitoba, though a part of those hatched near the 49th parallel probably went south of that line. The dry season must have brought them to maturity rapidly, for in some parts of the province they arrived earlier than before known, though coming from the latest hatching grounds.

When examined in detail, the advance of the host loses to a considerable extent the definite form which it appears to have when more broadly viewed ; for the grasshopper, like a sailing vessel, depends on the wind for propulsion, not having intrinsic power of swift flight ; and the movement of the different bands is affected by all the mutations of the weather. Even omitting a few dubious dates, the well authenticated ones show a difference in the times of arrival in some parts of Manitoba, not corresponding with their geographical position. It appears certain that one extensive swarm traversed a part at least of the province north-eastward. They reached the Red River further south at Scratching River on July 11th. We hear of them on July 8th and 10th at St. Norbert, on the 14th at Winnipeg ten miles off, on the 17th at Little Britain seventeen miles further in the same direction. Swarms also arrived at Fort Ellice—180 miles west of Red River—with a similar direction of flight, on July 14th, or on the same day that they arrived at Winnipeg. These must have been a separate body travelling parallel to the first.

These dates only refer to the first arrival of locusts in considerable numbers, and the localities mentioned were afterwards traversed by other swarms. The second main direction of invasion, was from west to east, with occasional slight local deviations, and was that followed by most of the insects. Bands first appeared within the limits of the province on the Assineboine River at Portage La Prairie on July 3rd. They seem to have travelled eastward along the river, reaching Poplar Point—fifteen miles off, on July 12th ; other and very extensive swarms are heard of north-westward of Portage La Prairie, at Beautiful Plain on July 15th, at Burnside, July 17th, Palestine, July 19th ;

and on the 18th and 19th at St. Laurent, on the eastern shore of Lake Manitoba. On July 11th we find other hordes at Pembina Mountain, on the boundary line, and these in the course of their migration reached West Lynne on the Red River —thirty miles distant on the 15th.

On July 11th the front of the various swarms would be approximately bounded by a line drawn from Pembina Mountain on the forty-ninth parallel, to Scratching River, thence following the Red River to a point between St. Norbert and Winnipeg, from there probably bending southward through a region for which we have no information, but again turning northward, and striking the Assineboine a few miles west of Poplar Point, and thence running—though no doubt with many flexures—north-north-westward.

It will be observed that while great swarms of the locusts had thus nearly reached the eastern border of their range, there were still immense numbers just beginning their migration about the 107th and 110th meridians. These are no doubt the hordes which according to the Hon. Mr. McKay arrived in Manitoba during August. The directions taken by the insects on their departure from the various localities in Manitoba, show much diversity. They often remain some time on the ground, and after depositing their eggs they are weak and their organization is broken.

The most astonishing fact in connection with the habits of the locust is the fixed determination of the swarms to travel in a certain direction, and the wonderful instinct which leads them to wait for a wind favouring their intention. The usual direction of migration when swarms fall upon the cultivated lands and settlements, is south-eastward or eastward, and to this there is abundant testimony. There is evidence, however, that the insect occasionally migrates in great bodies in a nearly opposite direction, and in 1875 it would appear that many swarms, the progeny of those of 1874, have shown a like decided inclination to travel northward, toward the breeding grounds of their parents, while yet in their full strength and vigour. It would be a fact surpassing in interest the journeys of birds of passage, if it should be found that the locust requires two generations to complete the normal cycle of its migration.

The locusts are recorded on one occasion at least (1867, by Prof. Hind) to have reached the shores of the Lake of the

Woods, but I have not heard that they did so in 1874. Their limit in this direction is pretty definitely fixed by the western margin of the great woods, about long. 96°. They did not appear at Fairford Port, on the northern part of Manitoba Lake, nor at Swan Lake House (long 100° 30′. lat. 52° 40′), Cumberland House (long. 102° 30′, lat. 54°), Prince Albert (long. 105° 30′, lat. 53° 10′), or Fort Pitt (long 109° 20′, lat. 53° 30′). They are very seldom seen at the second, and never at the third and fourth of these localities. The exemption of Prince Albert is noteworthy and instructive, as, on the testimony of several gentlemen acquainted with the locality, it is due to a *belt of coniferous timber*, which stretches between the North and South Saskatchewan Rivers here; and though grasshoppers in great abundance have visited the country south of the line thus formed, *they have never been known to cross it.*

The only crops which under ordinary circumstances the locust will not eat, appear to be sorghum and broom corn; but besides a general preference for those plants which are tender and juicy, it shows a considerable degree of aversion to certain species, and these generally escape when the insects are not in very great number. Potatoes, beets and tomatoes are usually thus exempt, and a very decided dislike is shown to the *Leguminosæ* or plants of the pea and bean family. May not this last fact serve to explain, to some extent, the vast number of leguminous plants found on the western plains, which have no doubt been subject for ages to the ravages of grasshopper armies? In *Astragalus pectinata* the leguminous flavour is developed to a very offensive extent. I have seen *A. adsurgens* stripped of its flowers by the locusts, while the leaves, though young and tender, remained entire.

Experience abundantly proves that in years when foreign swarms are to be expected, wheat is one of the safest crops, as it is very generally too far advanced to be much injured at the time of their arrival. It is essential, however, that it should be as early as possible.

It seems hardly necessary at this date, to review all the means which have been proposed or tried, on a more or less extensive scale, to protect crops from winged swarms, or to destroy the eggs and young insects. Methods applicable with advantage to well settled countries, are not useful, or only to a very limited extent, in those with much waste land in proportion to the cul-

tivated, yet by persistent and combined effort much may be done towards the protection of limited areas, by disturbing and harrassing the winged insects on their arrival in summer, and by collecting and killing the eggs and young brood in autumn and spring. A great area of the western plains incapable of cultivation or use for other purposes than stock raising, must, however, always remain as a breeding place for the locust, and it is only by the application of some broad and general remedy, if such can be found, that permanent amelioration can be effected. It would seem possible by an organized system of supervision, and the division of a large part of the prairie region into blocks protected by rivers and other natural fire-guards, and by ploughed lines, to prevent the general spread of prairie fires in the autumn, and afterwards to destroy the young locusts by burning the grass off over those areas found to be tenanted by them in spring. A similar course is urged by Dr. Studley as worth trial. Mr. Mair informs me that it has been attempted in the spring of 1875 near Portage La Prairie without effect; but by choosing a time when the grass is dry, the wind moderate, and the young insects pretty well advanced, it seems scarcely possible that many should escape. Again, when winged swarms are known to be moving on the province, making use of a similar system of fire-guards, it would be possible to form by preconcerted firing a strip of black country of great width, altogether beyond its limits, over which it is improbable the locusts would voluntarily attempt to pass. The extensive planting of trees in all the cultivable districts, besides probably effecting a climatic change causing increased damp and rainfall, which would be unfavourable to the locust, would so break up and divide the now uniform surface of the country as to prevent the destruction of crops being so universal as it now sometimes is. Coniferous trees, from the experience of Prince Albert Post, seem specially worthy of attention.*

It is my intention in a future paper, to summarize and discuss the facts concerning the grasshopper visitation of 1875, with especial reference to Manitoba and the North-west Territories, and I shall be much indebted for any particulars which will help me in this object.

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*This and other points will be found more fully treated in my Report on the Geology and resources of the regions in the vicinity of the 49th parallel, 1875.

The following is a summary of the more important items of information for the summer of 1874, the localities being arranged in order from west to east:—

Battle River and Red Deer River, North West Territory.—(W. McKay, from reports of H. B. Company's officers) A tract of country extending sixty miles north and south, and fifty miles east and west between Battle River and Red Deer River. Grasshoppers produced from the egg about the beginning of June. Left about the end of July, going southward from the Battle River.

Fort Pitt, North West Territory.—(W. McKay). Did not appear within 140 miles of this place.

Observations in the vicinity of Wood Mt. and Westward.—On the 7th, 8th, 9th, and 10th of July, I noticed grasshoppers in great abundance on the high plateau of Wood Mt. (long. 106° 30′) and its vicinity. They were migrating eastwards with the prevailing winds during the warm hours of the day, and flying at a great height. On the 12th they were met with in vast numbers covering the country to the west of White Mud River (long. 107° 35′.)

Swarms were also observed by other members of the Boundary Commission parties, on the 9th, 10th and 11th of July, at numerous points between long. 108° and 109° 30′, the last named meridian being about the western limit of the main horde at this time. Their general direction of travel was eastward, with the wind. On July 11th, their course is stated at several localities to have been south-east.

It would thus appear that on July 9th to 11th, the width of the belt of grasshopper-covered country was about 150 miles on the forty-ninth parrallel, stretching from beyond the West Fork of Milk River nearly to Wood Mountain.

Carleton House, North West Territory.—(L. Clarke.) Produced from the egg in 1874 almost immediately after the disappearance of the snow, early in May. When full grown took flight southward. Foreign swarms appeared in the beginning of September and stayed all the autumn. No crops put in here.

Mr. Clarke writes:—East of this there is a settlement called Prince Albert, about fifty miles distant. Between us and this place there is a tract of sandy soil covered with a forest of fir.

Strange to say the grasshoppers have been in myriads from Carleton to the boundary of this timber, but none on any occasion have ever passed it, or troubled the farmers of Prince Albert.

Prince Albert, North West Territory.—(Philip Turner). No grasshoppers appeared here.

Missouri Coteau, North West Territory.—Long. 105° 30′, lat. 49° 30′. On June 19th, 1874, I passed over about twenty miles of country near the western edge of the Tertiary Plateau, which was covered with young grasshoppers, not yet able to fly.

Fort Qu'Appelle, North West Territory.—(Wm. J. McLean.) Produced from the egg, hatching from early in May to the beginning of July. On July 25th began to take flight, going south-east by south. Foreign swarms were first observed about July 20th coming from north-west, and north-west by-north. Continued passing for ten or twelve days, and remained on the ground only while contrary winds lasted. All were gone early in August, and no eggs were deposited.

Crops totally destroyed before the insects began to fly. Mr. McLean observes, that the insects before they were able to fly, took certain directions for several days at a time, and all travelled simultaneously in the same direction.

In 1875 full grown insects appeared June 17th in myriads. Seemed to come from about the same direction in which they flew from here last year, but rather more southerly.

Wood End, North West Territory.—Long. 103°, lat. 49°. Dr. Burgess on July 1st and 2nd noted grasshoppers flying westward with the wind. They are said to have been very numerous. (The wind at Wood Mt., 150 miles further west, was variable on these days, changing from south-east on the first, to east-north-east, south and north-north-east on the second.) The observed direction of flight is abnormal.

Cumberland House, North West Territory.—(H. Belanger.) Grasshoppers never known to appear here in swarms.

Fort Ellice, North West Territory.—(R. McDonald.) Not produced from the egg here. Arrived in swarms July 14th, from the south-west. Left July 17th, after devouring all the crops, going north-east. Eggs were deposited and some were

observed to hatch in the autumn. (On June 7th, 1875, the young insects had already destroyed all growing crops.)

Swan Lake House, North West Territory.—(D. McDonald.) The grasshoppers did not appear here this summer, and are said to do so very seldom.

Beautiful Plain, North West Territory.—(Prof. Bell, Geological Survey of Canada.) Not produced from the egg here. Swarms arrived on the wing July 12th and were nearly all gone July 15th. Came from the west, and departed about east-south-east. Eggs were deposited in great numbers in gravel and sand ridges, on badger mounds, &c. Very few were observed to hatch in autumn. Between Prairie Portage and Headingly about two-thirds of crop destroyed.

Manitoba House, North West Territory.—(J. Cowie, J. P.) Not produced from the egg here. Swarms arrived about the third week of July, from the south-west, but not in great numbers. Passing over the place for about a week, going generally south-east. Eggs were deposited.

Crops destroyed, about one-tenth.

None were seen to the north of this place. Multitudes were drowned in the lake (Manitoba Lake), on the shores of which they were piled up in masses three feet deep.

Fairford Post, North West Territory.—(J. Cowie, J. P.) No swarms of grasshoppers have as yet appeared here.

Palestine, M.—(D. Ferguson.) Not produced from the egg here. On July 19th a few appeared, and were afterwards followed by great swarms coming from the north-west. Insects left about July 30th, going north-east. No eggs deposited.

Destruction of grain total, of potatoes one-fifth.

Burnside, M.—(K. McKenzie). Half-breeds told Mr. McKenzie that grasshoppers were very thick in the Saskatchewan country, and within sixty miles of Burnside on July 14th; on July 17th they arrived. Came from the west, and kept pouring in till July 22nd, being most numerous on July 19th. By July 29th had nearly all gone. Direction of flight on departure east or north-east. Eggs were deposited.

Wheat crops at Burnside averaged 16 to 20 bushels per acre against 28 to 32 in former years; in western settlements not

4 bushels per acre. Oats and barley nearly all destroyed. Potatoes not much damaged. Turnips half crop. Peas uninjured. Carrots nearly all taken. Onions one half. Beets and mangolds hardly touched.

The grasshoppers made their appearance, especially in the western part of the province, earlier than ever before. Mr. McKenzie was informed by the half breeds that the insects hatched at Qu'Appelle and other western localities, and that very few were left there to deposit eggs in the autumn of 1874. Mr. McKenzie also writes, "I was at Lake Manitoba, twelve miles north, about August 10th. Grasshoppers were dead and dry on the shore from four to ten inches deep, and from twenty to thirty feet wide as far as I could see all along the beach."

Portage La Prairie, M.—(Charles Mair). Not produced from the egg here. Swarms first seen about July 3rd, coming from the west. Left about July 10th, going eastward. Many eggs deposited. Crops destroyed. Oats seven-eighths, barley three-fourths, wheat one-half. Potatoes not much injured; gardens much damaged.

Mr. Mair also observed the grasshoppers to be covered with parasitic mites, and the presence of the larva of an ichneumen in the bodies of many of the insects.

Poplar Point, M.—(L. W. McLean.) Not produced from the egg here. Swarms first appeared July 12th from the west. Insects left about the last of July, going east. Eggs were deposited.

Barley and oats totally destroyed, wheat one-third.

Pembina Mt., M.—(Lt. Col. French, Commissioner N. W M. P.) First met large flights of grasshoppers at Pembina Mt., July 11th. They were going eastward, and continued to appear for several days while Col. French travelled westward but were afterwards no more noticed. The grass from La Roche Percée to the Old Wives Lakes, and possibly to the Cypress Hills, appeared to have been eaten down by grasshoppers. In the vicinity of the Three Buttes, no such appearance.

They nearly destroyed a field of grain sown by the Mounted Police at Fort Ellice.

St. Laurent, M.—(J. Mulvihill.) Not produced from the egg here. Swarms appeared July 18th and 19th from the west and north-west. Left about August 4th, going southward. Eggs were deposited. At least one-fourth of crops destroyed.

Headingly, M.—(John Taylor). Not produced from the egg here. Swarms arrived from the south, and from the west, about the first week of August. The majority remained till about the first of September and then went southward. Some stayed till the end of September. Eggs were deposited and a few of them hatched in the autumn and the young insects were killed by the frost. About half the crops destroyed.

St. Charles, M.—(W. Adshead). Not produced from the egg here. Appeared about the middle of June (?) from the west. Most remained till killed by frost, though a few went southward after depositing their eggs. Destruction of barley and oats total, wheat one-third, potatoes somewhat injured.

Rockwood, M.—(J. Robinson). Not produced here from the egg. Swarms appeared about the last of July from the south and west. Departed about the middle of August, going south and west. Eggs were deposited, a few were hatched in autumn and the insects destroyed by frost. More than half the crops destroyed.

Scratching River, M.—(W. C. Cowan). Not produced from the egg here. Swarms arrived July 11th, from the southwards, bearing westerly. Left July 16th, going northward. Eggs were deposited and some insects came out and were killed by the winter. Crops destroyed, two-thirds.

West Lynne, M.—(Colton M. Almon.) Not produced here from the egg. Swarms arrived on July 15th, about 11 a.m., from the westward. Commenced rising early on the morning of July 22nd, and by noon had disappeared. Direction of flight, north. Eggs were deposited, and it is reported that many hatched in the autumn. Oats and barley, two-thirds destroyed, wheat about one-fourth, potatoes a little damaged.

St. Norbert, M.—(Joseph Lemay, M. P. P.) Not produced from the egg here. Swarms first seen July 8th or 10th, and arrived both from the south-west and north-west. Remained about seven weeks, departing south-eastward. Eggs were depo-

sited, but many said to have been destroyed by "small red insects." The whole of the oats and barley, three-fourths of wheat, and four-fifths of garden stuff destroyed.

St. James, M.—(Hon. J. McKay.) Mr. McKay furnishes various particulars, from which I extract the following points of interest:—No grasshoppers were hatched in Manitoba in 1874. The nearest breeding ground for the swarms is said to have been about 250 miles west, and thence to extend westward for about 400 miles. The nearest swarms moved in July and passed St. James overhead, going eastward, about the end of July. Other swarms from further west arrived about the beginning of August, and left after a few days without doing much damage. Then came larger swarms till the middle of August, carrying everything before them. Estimated that two-thirds of crops of entire province destroyed.

Winnipeg, M.—(James Stewart and R. H. Kenning). Not produced from the egg here. Swarms arrived July 14th from south-west, and the majority remained about two months, leaving about the middle or end of September, and going to the west and north-west. Many remained, however, till killed by frost. Eggs were deposited about the end of August, and it is reported that some young insects came out and were destroyed by frost in autumn.

The whole of the oats and barley, and about one-fourth of wheat destroyed.

Mr. Stewart observed that nine-tenths of the grasshoppers had small red parasites under the wing, and that those remaining late in the autumn had, almost invariably, each a fully developed grub within it.

Little Britain, M.—(Hon. D. Gunn.) Not produced from the egg here. Swarms first appeared July 17th, from the south and south-west, and continued passing over the settlement till the last of August. Those that alighted deposited eggs, and generally left afterwards east or south-east. Many eggs deposited. Crops destroyed, about one-third.

In a more recent communication (February, 1876), Mr. Gunn states that, the spring of 1875 having been late, the young locusts from the eggs began to appear about the tenth of May, and continued to come out until the end of that month. They

were very numerous and destructive, but he noticed that many were attacked with a small red parasite. When mature, the swarms went, in part at least, to the north; and some were stated to have deposited their eggs near Lake Winnipeg. Other facts contained in Mr. Gunn's letter I hope to include in the report for 1875.

Stone Fort, M.—(W. Flett.) Appeared in swarms from the south and south-west, generally departing easterly. Eggs deposited, and some hatched in autumn.

Cook's Creek, M.—(G. Miller.) Not produced here from the egg. Swarms appeared about July 26th from the north-west. Remained about two weeks and departed south-eastward. Many passed overhead without alighting. Crops about two-thirds destroyed.

St. Ann's, M.—(J. H. Stanger). Not produced from the egg here. Swarms first seen July 22nd, and coming from west-by-south. Continued arriving and departing for about two months, some leaving in the latter part of September, but many remaining till they died. The first swarms went from here eastward, the last more to the south. Eggs were deposited and some were hatched in autumn.

Barley, oats, potatoes and vegetables suffered most. Some wheat escaped. Peas suffered least of all field crops.

NOTES ON NORTH-WESTERN AMERICA.*

By Alexander Caulfield Anderson, J. P. (Formerly of the Hudson's Bay Company.)

Watersheds.—The main continental watershed is of course the general line of the Rocky Mountains, which continue through Alaska to the extreme point, near Cape Lisburne. There is, however, an exception to this general rule near the heads of Peace River, where the main chain is disrupted, and the waters originate in the Peak Range of Arrowsmith's Map, which range here forms an extraordinary loop with the main line. Both afterwards unite with the N.W. Coast Range, and continue as one, nearly as far as the 60th parrallel, where a divergence again takes place, and the Southern Coast Range of Alaska originates.

The Sierra Nevada, the chief range of California, separates near the frontier of Oregon; the eastern branch, known as the Blue Mountains, dividing the waters of the main Columbia River from those of its great tributary, the Snake; the western, under the name of the Cascade Range, continuing north-westward into British Columbia, as far as the junction of the Thompson with the Fraser in 50° 13′, where it terminates. The Cascade Range is disrupted at a point between Mounts Hood and St. Helens; the Columbia River then breaking through and forming a strong rapid known as the "Cascades," whence the name given to the range. This name, however, originates not from any peculiarity in the rapid itself, but from several lofty waterfalls, formed by streamlets pouring down the perpendicular face of the disrupted mountain in the immediate vicinity. The height of the passes in this range varies from 3,000 to 5,000 feet; the peaks sometimes rising to an altitude of 15,000. Mount Rainier, the most lofty of the northern portion, has an elevation of 12,360 feet. Most if not all of these summits are volcanoes, either extinct or in partial eruption at distant intervals. It may here be mentioned that the term

* Descriptive matter intended to accompany a "Skeleton Map of North-West America," prepared by Mr. Anderson to send to the Philadelphia International Exhibition of 1876.

"Cascade Range," through a total misapprehension of the leading features of the country, has of late years been extended so as to include also the North-West Coast Range, from which the true Cascade Range is geographically quite distinct. Hence much confusion has arisen. Against this perversion I have always protested; and now once more endeavour to restore the distinction before most properly made by the original explorers, and established on their maps.

The North-West Coast Range, just referred to, originates opposite to Langley near the mouth of Fraser River, and continues north-westward, nearly parallel with the coast, till it is merged in the Rocky Mountains between 56° and 57°—thus forming the whole western watershed of Fraser River, as the northern part of the Cascade Range, with its offset connected with the Rocky Mountain Columbian spur, does the eastern. The contour of this range, especially on the coast-ward side, is extremely broken and irregular; its rugged spurs forming the sub-divisions between the numerous arms with which the north-west coast is indented. As we advance northward, however, the summit itself is not of a broken nature; but exhibits a vast plateau, yielding lichens and other congenial vegetation, together with a stunted growth of pines in parts. This portion of the range is the resort of innumerable Rein-deer of the mountain variety, and abounds also with Ptarmigan. Its elevation opposite to Bentinck Arm, between lat. 52° and 53°, is 4,360 feet, and at the head of Bute Inlet Pass, where the characteristics are somewhat different, 3,117 feet; but there are other points where depressions occur, as for instance between Stuart and Babine Lakes, where the altitude does not probably much exceed 2,000 feet above the sea level. The highest summits in parts, rise to about 10,000 feet; but amid the general ruggedness of contour there are no strikingly conspicuous peaks as on the Cascade Range.

Diverging from the Rocky Mountains near the 49th parallel is the ridge forming the *Southern and Eastern Watershed of Hudson's Bay*.—Under the varying cognominations of Coteau de la Missouri, Coteau des Prairies, &c., this watershed, passing the heads of the Red River, forms the northern and western boundaries of the Provinces of Ontario and Quebec, and, dividing Labrador, terminates at Hudson's Strait, opposite to Southampton Island. The average elevation of the Prairie

portion of this ridge, as given by Mr. G. M. Dawson, is 2,000 feet. The western and northern portions of this vast watershed are the Rocky Mountains as far as the head of the North Saskatchewan. From this portion of the watershed, in about lat. 64°, the range forming the Arctic watershed diverges, terminating at the mouth of the Mackenzie.

Alaska.—The Kwitchpak or Yukon is the principal stream of this extensive region—a river of very considerable magnitude. The Hudson's Bay Company have long had posts on the upper waters of this stream, within the British territory ; but it is chiefly from the reports of the party sent for exploration in connection with the projected telegraph through Siberia that our knowledge of the lower portion is derived. Thence it appears that the river is navigable for steamers for 1,000 miles or more ; that the ice breaks up about the 23rd of May, and that navigation is practicable about the 25th. The length of the Yukon, including its windings, I compute to be about 1,600 English miles. The volume of water ejected by it, according to the accounts received, is probably not less than that emitted by the Mackenzie ; but the area drained by it and its tributaries (about 229,000 square miles) is very much smaller. Hence it may be inferred that the snow-fall in the mountains of Alaska is proportionately heavy, a result readily conceivable from its geographical position—directly interceptive of the vapour-drift from the Pacific. The upper portions of the Yukon and its tributaries, the Porcupine and other streams, are well wooded, and abound with animals yielding furs of a quality peculiarly fine. Moose-deer are numerous along the rivers and in the lower elevations. In the more precipitous ridges of the mountains the Wild Goat is found ; on the sloping spurs the Mountain Sheep or Big-horn. Rein-deer are numerous ; the larger variety frequenting the interior parts, the smaller, or Barren-ground Rein-deer the coastward tracts. Fish of various kinds are numerous in the waters ; and among these, two varieties, at least, of Salmon periodically ascend from the sea. The larger of these (*Salmo dermatinus*, of Richardson) attains a weight of from forty to fifty pounds ; the smaller (*S. consuetus*) from twenty to twenty-five pounds. The natives of the interior of Alaska, distinguished as the Koochin tribes, are a branch of the great *Dinnee* (or '*Tinneh*') family. The Koochins have the character of being industrious, and are in many respects a somewhat superior race. They are divided into some

twenty or more different septs, each bearing a specific cognomen with the general affix "Koochin," meaning I believe "people." Approaching the coast the country assumes the generally desolate aspect of the Arctic Ocean confines, and the Esquimaux occupy the immediate sea-board. It is probable that with time mineral deposits of various kinds may be developed in Alaska. So far copper is known to exist in parts; and during the past summer some gold-seekers have been working upon streams falling into Cook's Inlet, the daily yield of whose labours is reported to have been moderately productive, averaging from $4.00 to $5.00 per man. Fossil ivory, as on the Siberian shore, is known to exist in the northern part of Alaska, adjoining Behring's Strait.* The name Alaska I believe to be a modification of the term for this coast employed by the natives of Kamtchatka; who,according to Benyowski(Voyages et Mémoires, &c. Paris 1791) distinguished the main shore of America as Alacsina (or Alacsa), the termination being apparently an affix. The Point "Le Grande Alacsina" mentioned at page 413 of vol I, I identify with what is now known as Cape Prince of Wales.

Mackenzie River.—This river, with its tributaries, drains an area of about 520,000 square miles, or more than double that drained by the Yukon. Its length from the mouth on the Arctic Ocean to its remote heads in the Rocky Mountains, by the line of Peace River, and including windings, is little, if at all, short of 2,000 miles. Unlike the Yukon, there are several lakes of very large dimensions connected with it. The lower part of the Mackenzie shares the generally barren and inhospitable nature of the Arctic coast; and there is little vegetation beyond a few stunted willows, the cranberry, the widely distributed "Labrador Tea" (*Ledum palustre*) and other products of a congenial class. Yet even amid this scene of desolation, Mackenzie noticed, in July, tracts of luxuriant grasses mingled with gay flowers, covering the iec-bound soil; just as navigators have noticed the same seeming anomaly in Kotzebue Sound and elsewhere along the Strait of Behring. Rein-deer are the only species of the family found here; Foxes of several varieties, including the white (*Vulpes Lagopus*) occur; also the Marmot, the Bear,

* Kotzebue, in 1816, when landed on Chamissa Island in Kotzebue Sound, discovered the remains of *Elephas primigenius*, apparently portions of a large deposit, imbedded in the land ice.

&c. In addition to the many kinds of migratory water-fowl that resort to these localities to breed, the white Grouse or Ptarmigan (*Lagopus albus*) appears abundantly as a permanent resident, as indeed along the whole Arctic watershed and the shores of Hudson's Bay. The White-fish (*Coregonus*), several varieties of Carp, Trout, and other fish, including the Inconnu (probably grayling, *Thymallus signifer*, of Richardson ?), are common to the stream and its tributaries. The Pike also is found, but no Salmon ascend this river ; which in this respect forms probably the solitary exception among all the larger streams from California upwards to this point. For the deficiency of this valuable fish there is no apparent cause ; nor does there seem to exist any reason why it should not be artificially introduced at some future day. Higher up, as we approach the discharge of the Great Bear Lake, the evidences of an improving climate appear. The Service-berry (*Amelanchier*), the Wild Gooseberry and other fruits are common ; the country throughout is well timbered, chiefly with varieties of fir and pine ; and a greater variety of beasts of the chase, including the Moose, the Beaver, &c., appear. Little has been ascertained of the mineral characteristics of the lower Mackenzie ; but Sir Alex. Mackenzie, whose name it bears, mentions a seam of coal (or lignite ?) which was on fire when he passed in 1789 ; and which was noticed by Dr. Richardson, still in a state of ignition, as late as the year 1848. Upon the heads of the Rivière aux Liards, an extensive tributary joining from the southward, productive gold-beds have been wrought for the last three years ; and here, within the limits of British Columbia, under the name of "Cassiare," a settlement has been formed in connexion with this alluring, if precarious, industry. This river, it may be mentioned, derives its name from the profusion along the banks of its lower portion, of the Cotton-Wood Poplar (Liard = *Populus balsamifera*.) It is needless to add that in the mouths of the many, the name has already been wonderfully transformed.

Peace River.—The lower portion of this tributary of the Mackenzie, after its junction with the Athabasca, where it is upwards of a mile in breadth, is known as the Slave River ; a name originating with the Cree Indians, who applied the designation (*Awâh-can*, or slave) in derision of the lower Chipewyans, who were formerly treated by them as enemies, and whom they had driven from their lands. Towards the end of the last

century a general pacification of the hitherto hostile tribes took place, a treaty of amity having been concluded at the spot since known as Peace Point. Hence the name of La Rivière a la Paix, now translated into "Peace River," given to the stream by the first explorers. Its original name, however, is Unjigah, the signification of which, if haply it have a signification, I have never been able to ascertain. The whole extent of country through which this noble river flows, from the point where it breaks through the Rocky Mountains (*vide supra*) to its junction with the Athabasca, is very attractive, and a vast area for future settlement is presented. The want of space will prevent my dwelling on the charming features exhibited by this beautiful region; and I merely remark that its general characteristic is that of extensive plains, stretching on either side clear up to the foot-hills of the Rocky Mountains and their several spurs, and amid which groups of aspens, &c., are picturesquely interspersed. With reference to the climate of this portion of the country, the mere consideration of latitude would, if entertained, mislead the uninformed enquirer very gravely. A glance at the isothermal lines will show that leaving the Atlantic coast they trend abruptly northward till they reach the vicinity of the Rocky Mountains; and finally the actual difference of the mean temperature as between positions on the Atlantic and the Pacific, may be stated in approximate terms as about ten degrees Fahrenheit in favour of the latter. Hence the denizens of the Peace River country and the Saskatchewan enjoy a climate far more genial than might be supposed. The confined space at my disposal prevents my entering upon any prolonged discussion of this interesting theme, to which, however, I may again incidentally refer. I content myself by remarking that the snow, in most parts, seldom accumulates to a greater depth than eighteen inches on the levels, the warm south-west winds, of frequent recurrence during the winter, at once diminishing it, or at times removing it almost entirely from all the lower land. The river opens about the 25th of April, and is closed for navigation at the beginning of November. I shall here, however, avail myself of the valuable notes of Professor J. C. Macoun, drawn from the railway reports and other sources. At Fort Vermilion on the 6th of August (1875), lat 56°. 42′, barley ripe and cut, and on the 12th wheat and oats fit for reaping. At Fort McMurray at the forks of the Athabasca, an excellent garden

containing many kinds of vegetables, including fine cucumbers. At Isle à la Crosse (English River) potatoes still in the ground on the 22nd September, there not having been any frost up to that date. Mr. Selwyn, Director of the Canadian Geological Survey, is reported to have brought down samples which will doubtless appear at the Centennial Exhibition ; viz.: Spring wheat from Fort Chipewyan (Athabasca Lake), lat. 58° 45′, weighing sixty-eight pounds to the bushel—sown May 22nd, reaped in August. Barley from the same place weighing fifty-eight pounds to the bushel ; and oats from Fort St. John on the Peace River, on the verge of the Rocky Mountains. The leading vegetable forms observed by Mr. Macoun in the Prairie section around Dunvegan, are as under :—

Anemone Virginiana.
" patens.
Geum triflorum (Bennet.)
Potentilla arguta.
" Pennsylvanica.
Amelanchier Canadensis, (Service berry.)
Achillea millefolium, (Yarrow or Millefoil).
Rosa blanda.
Hedysarum boreale.
Solidago (Golden Rod), two species.
Aster multiflorus.
" lævis.
Orthocarpus luteus
Troximon glaucum.
Oxytropis splendens.
Elæagnus argentea (Silver-berry.)
Vicia Americana (Vetch).
Artemisia frigida.
" discolor.
Bromus Kalmii.
Triticum repens, &c.
Aira cæspitosa.
Lathyrus ochroleucus.
Poa serotina.
Stipa Richardsonii.
" membrancea.
Trisetum subspicatum.
Calamagrostis Canadensis.
" stricta.

Mr. Macoun adds that every plant on this list grows also at Edmonton, on the Saskatchewan, and all grow where wheat will come to perfection. But nothing, perhaps, can more satisfactorily prove the true prairie character of the country than the fact mentioned by Mr. Macoun, that at Dunvegan he found growing the Disc-leaved Cactus (*Opunita Missouriensis*) which is always indicative of a dry locality with a considerable degree of mean annual heat. The whole of this region once abounded with herds of Bison, as still do parts of the Saskatchewan ; but the remnants are now found only in remote places on the outskirts of the Rocky Mountains. Other beasts of the chase, such as the Rein-deer and the Moose are still numerous ; while in the mountainous parts the Rein-deer, the Goat, the Mountain Sheep, the ordinary varieties of the Bear (black, brown and grizzly), &c., abound.

Athabasca River.—This is reached on crossing the divide, between it and Peace River. The summit of this divide, composed of a swampy plateau with a vegetation of corresponding nature, does not probably exceed 2,000 feet in height—that of Lesser Slave Lake, on the one hand, and Dunvegan on the other, being estimated, the former at 1,800, the latter at 1,000 feet above the sea-level. The banks of the Athabasca River are generally less inviting in appearance than those of the Peace. The lower portions, however, present many attractive features; and the climate, as indicated by the extract given above, is encouraging for agriculture. The borders upwards, are for the most part thickly wooded with the Spruce and *Cyprés* (*Pinus Banksiana*) interspersed with the Balsam Poplar, the White Birch, and other deciduous trees. Animals of the various kinds mentioned abound throughout in their fitting localities, while fish of the finest description are yielded by the lakes. Athabasca Lake, it may be here mentioned, is noted for the innumerable flocks of water-fowl which resort thither as a favorite breeding place, and which at the proper seasons yield store of food to the inhabitants. The mineral riches of the tract drained by these large rivers are varied; at the head of the Peace, on the borders of the Peak Range, there are extensive gold diggings, known as Omineca, which are moderately productive, though now partially abandoned for richer fields. Coal, reported to be of good quality, is found at several points upon the Athabasca; while favourable indications appear upon the Peace. Bituminous pits exist in several places along the lower Athabasca; yielding an apparently inexhaustible supply of pure mineral tar. The product of some of these, duly prepared by boiling, &c., has long been used for pitching the boats employed for transport. Smoky River, falling into the Peace above Dunvegan, has its name from beds of coal or lignite, which were on fire when Europeans first visited the country, if indeed yet extinct. Mineral Salt is found between Athabasca and Great Slave Lakes. Near the mouth of the "Salt River" it appears in the form of a thick incrustation on the borders of the springs, and requires merely to be shovelled into bags. The salt thus procured has from the first been the sole resource of the European residents, and is of an excellent quality for all domestic purposes.

The Barren Grounds may be defined as extending from the watershed immediately north of Churchill River to the

Mackenzie, along the slopes towards Hudson's Bay and the Arctic Ocean. As shown in a previous note, referring to Isle à la Crosse, the soil and climate along the upper portion of the former stream are sufficiently favourable for agriculture; but lower down, and proceeding northward and westward, the whole region is extremely desolate and inhospitable. This is occupied by a portion of the great Chipewyan or Tinneh tribe, who regard it as the cradle of their race, whence they claim to have spread in other directions. Little description of this desolate region is necessary, beyond that information which the general reader will already have acquired from other sources. A few stunted shrubs of the hardiest kinds—dwarf birch, willows and the like—scantly clothe the more favoured spots along the water-courses; while elsewhere various lichens, the peculiar food of the Rein-deer, interspersed with stones and stagnant water-pools, alone characterize the dreary scene. Yet amid these unattractive wilds the natives obtain an abundant, if at times precarious, subsistence, by fishing and the chase. Rein-deer (of the smaller variety) are extremely numerous during the period of their northern migration, commencing in March; and the Musk-Ox (*Ovibos Moschatus*) finds in these solitudes a congenial and perennial field. On the immediate sea-frontier the Polar Bear appears; but no other of the larger quadrupeds than those enumerated I believe is found. The Beaver, common to nearly every portion of North America, shuns a scene where all its industry would fail to procure its living; and it is not till the hunters reach the line of about the 65th parallel that they are able to procure the fur of this animal for the purposes of barter. The Ptarmigan is found in abundance, as also the White Fox; with Wolves, some of which are white, and in parts the Arctic Hare (*Lepus variabilis*). Most of the lakes are well stocked with White-fish and other kinds; and probably Salmon, of some of the numerous varieties, ascend all the larger rivers between the Churchill and the Mackenzie, in neither of which do they appear. A variety called the "Copper Mine River Salmon" (*Salmo Hearnii* of Richardson) is known to ascend the river of that name; and the native name of the Back River—*Thleu-e-chodezeth* (or *tesse*)—lead some to infer that that also is frequented either by this or some other variety. (*Thleu-e-cho*, literally "big-fish," employed by the *Tâh-cully* of the upper Fraser to designate the sturgeon, is on the Mackenzie applied to the salmon of the

Yukon). Of the minerals in this quarter little can be said; but from the name of one of the rivers before mentioned, and from report, we may be justified in believing that rich deposits of copper, at least, exist. The Esquimaux occupy the whole sea-board.

The Portage à la Loche, or *Methy Portage*, (Methy = Loche = Fresh Water Cod = *Gadus barbatula ?*) is on the dividing ridge between the waters flowing to Hudson's Bay by the valley of the Missinipi, and those tributary to the Mackenzie through the Athabasca. The summit of this portage, which is elevated very considerably above the general level, has an altitude above the sea, as given by Mr. G. M. Dawson on the authority of Dr. Richardson, of 1566 feet; but this estimate strikes me as somewhat underrated. The length of the portage is thirteen miles, over a level sandy plateau, stony in parts, and wooded with the Banksian Pine, the Spruce, and other trees. The northern side is a steep escarpment, descending by eight successive stages, all more or less precipitous, to the borders of the Clear-water, which flows by a course of some eighty miles, through a charming valley of mingled plain and forest, to the Athabaska, the breadth of the united stream being about three-fourths of a mile at the point of the union, called "The Forks." It is by this route, and the Portage de la Traite on the opposite side of the Missinipi Valley, that the transport is effected between Athabasba and Lake Winnipeg viâ the Saskatchewan. This last portage has its name from the circumstance that Mr. Frobisher, the pioneer trader from Canada, here intercepted a large party of Indians on their way to Churchill in 1774, and secured their hunts. By the Crees this portage, from an old tradition, is called *Athikesi-pichégan* Portage—i. e. Portage of the Stretched Frog-Skin. Hence, I presume, the name applied to it in some recent maps "Frog Portage"—but it is better known by the name given above.

Saskatchewan.—The general features of the tract drained by this river and the other tributaries to Lake Winnipeg are so well known that any attempt at description would be superfluous. The total area so drained, and discharged through the Nelson River, I compute at 376,000 English square miles: the length, including windings, from the mouth of the Nelson to the heads of the Saskatchewan, about 1,500 miles. The descent for a certain distance from Lake Winnipeg towards the sea, by the series

of lakes terminating in Split Lake, is necessarily very gradual ; thence, consequently, to its mouth the Nelson rushes with great impetuosity. It is owing to the series of rapids thus formed that the navigation of the lower parts is avoided ; and the ordinary boat route from York Factory to Lake Winnipeg is through Hayes' River and its connected waters, and over the divide by portage, striking the waters of Lake Winnipeg below Norway House. Thence to Edmonton on the Saskatchewan there are no impediments to the navigation of any moment, save the Coles' Rapids, near the confluence of the north and south branches, some twelve miles in length, which are navigable with care and skill, and the Grand Rapid near the mouth, where the river bursts through the ridge of limestone which forms the north-western boundary of Lake Winnipeg. The Saskatchewan becomes free from ice about the same time as the Peace River ; but the navigation from Edmonton is rarely attempted before the middle of May, when the waters have usually risen enough to float the loaded bateaux over the frequent shoals. Much of what has been said of the Peace River might be repeated of this region. The vegetation has the same general characteristics, and the climate is not dissimilar. Of minerals it may be remarked that coal has been discovered in thick seams in the vicinity of Edmonton ; and Mr. Selwyn is of opinion that, by boring, the seams may be struck at a small depth at various points, at least as low as Carlton near the confluence of the two branches. I may here incidentally mention that both at Edmonton and at Carlton the development of *goître* in the permanent residents is not uncommon. At the last mentioned post I have seen a whole family thus afflicted—the children exhibiting the marks of advanced cretinism. I am induced to think that the constant use of the river water, which is extremely turbid for the greater part of the year, without filtering or other preparation, is the proximate cause of this affliction, which does not attack the roving population, who are not confined to the use of the river water. The digging of wells, in such case, suggests the obvious remedy. I may add that I arrive at the conclusion stated the more readily, because that on Peace River, where the evil is also manifested in less marked degree, I have known a family who had partially contracted the disease during a long residence at Fort Vemilion, to entirely recover after a comparatively short residence at McLeod's Lake, at the head of Peace

River, where the waters are pure and limpid. There may, however, be deeper latent causes; but I suggest these which appear to me the more obvious. Yet even under this view there is a difficulty; for on Fraser River, where a similar condition of the water might be argued to produce a similar effect, no case of the kind has ever appeared. The Saskatchewan, like the Mackenzie, the Churchill, and I believe all the rivers falling into Hudson's Bay, is destitute of Salmon.

The West Side of the Rocky Mountains.—This region must be noticed very briefly. The lengths of the Fraser flowing entirely, and of the Columbia partially, within the limits of British Columbia, are respectively, including windings, the former about 800, the latter 1,200 miles; the approximate areas of drainage being, by the Fraser 66,400, by the Columbia 215,900 square English miles. Immediately on crossing the Rocky Mountains by the heads of the latter river, after the autumn frosts have already invaded the eastern side, a great improvement in the temperature is perceptible, while all the external evidences of a warmer climate appear. Descending the Grande Côte, within twenty miles of the summit, huge trees of the "Red Cedar" (*Thuja gigantea* of Nuttall) are for the first time seen; and lower down the timber and other vegetation are also different. About Colville the Columbian Red Pine (*Pinus ponderosa*) and the Larch (*Larix occidentalis*) of large dimensions are seen—the latter confined apparently to the vicinity of the 49th parallel, the former extending north-westward nearly to the great divide beyond the Thompson, and westward to the head of Anderson Lake near the Coast Range. About one hundred miles below Colville the borders of the great Columbia Desert are reached; extending thence, with occasional oases, as far as the Dalles of the Wascopum; and by the Snake River finally meeting with the deserts of the Youtah. Artemisia, the Cactus, and other congenial plants, characterise the whole of this arid tract; while the more favoured spots, near the water-courses, yield abundant pasture of rich Bunch-grass, and are extremely fertile. At one point upon the Okinâgan River, this arid waste extends for a short distance into British Columbia; and I do not question that, acting as a great reservoir of heat, the vast expanse exercises a marked influence on the temperature of the whole vicinity; and to the extension of this influence, partly, in conjunction with the warm winds from the Pacific, I ascribe

the general mildness of the climate upon the Peace River. On the lower Columbia, and through Oregon to California, the country is too well known for its fertility and resources to require comment.

British Columbia.—In British Columbia proper, the general features may be thus briefly summed up. Westward of the North-West Coast Range the whole tract is excessively mountainous, and penetrated by numerous inlets of the ocean. Eastward of the Coast Range (besides the intervening portion of the Cascade Mountains in the southern part), numerous ridges of moderate elevation appear, between which are broad valleys of great fertility, abounding with rich pasture, and partaking generally of the prairie character. The upper portion is more densely wooded, with fertile openings at intervals. The lower portions, along the line of the Fraser, with a generally dense growth of gigantic timber, present openings in parts of great fertility. The whole of the north-west coast, with a portion of Vancouver Island, is richly clothed with valuable timber of stupendous growth. In minerals the whole province is extremely rich. Nearly all the eastern coast of Vancouver Island abounds with coal; the most southern portion yet discovered being at Saanich near Victoria, where there is an apparently rich seam. The coal is esteemed of excellent quality, the chief export at present being from Nanaimo and its vicinity; and though some mines are wrought upon the neighbouring mainland, bordering on Puget Sound, the product does not command an equal price in San Francisco, nor is it apparently in demand. Iron ore, of the finest quality and easily accessible, with limestone for smelting purposes in the vicinity, exists in inexhaustible quantity on Texada Island near Nanaimo. Gold is found at the well known "Caribou Mines"; at the "Omineca"(i.e. "Mountain Whortleberry") diggings at the head of Peace River; at the head of the Dease tributary of the Rivière aux Liards, called "Cassiare" from the name of the reputed discoverer; on the upper waters of the Columbia near the Big Bend; on the Koutanais and elsewhere both on the mainland and Vancouver Island* Silver, not yet productively worked, exists in various parts of the Pro-

* The total yield of gold, however, from British Columbia in 1875 did not probably exceed three millions of dollars, of which about five-sixths only passed directly through the Banks.

vince, and especially at Cherry Creek near the head of the Okinâgan Lake,and at a point near Hope on the Lower Fraser. Copper is generally distributed along the north-west coast, in some parts very abundantly ; but so far has not been effectually wrought. A very rich deposit of galena, yielding a moderate percentage of silver, exists on the Flat-bow Lake (Koutanais), but the position is too remote and inaccessible for its profitable working. The Islands of Queen Charlotte, from what is already known, will probably be found extremely rich in all the metals mentioned, iron perhaps excepted. A seam of Anthracite coal of excellent quality was for a time worked there ; but for some reason has been abandoned.*

Prominent Vegetation in this Section.—(1.) Along the north-west coast : Douglas Fir (*A. Douglassii*, Lindl.) ; Spruce Fir (*A. Menziesii*) ; Hemlock Fir (*A. Canadensis* or *Mertensiana ?*) ; "Red Cedar" (*Thuja gigantea*, Nutt :) "Yellow Cedar" or Cypress (*Cupressus thyoîdes*, Doug.) &c. : all of gigantic growth. Undergrowth : various shrubby Vaccinia ; the "Sallal" (*Gualtheria shallon*) ; varieties of *Rubus*, *Ribes*, &c. In rare positions low specimens of Mountain Ash (*Sorbus aucuparia*) and Service-berry (*Amelanchier*).

(2). Along the vicinity of the 49th parallel as far as the Rocky Mountains. I here adopt the list of Dr. Lyall of the British Boundary Commission, reported in the proceedings of the Linnæan Society (Botany, vol. VII.) including my own occasional and purely unprofessional notes in brackets, thus [ ].

(a). In the vicinity of Victoria and Esquimault, Vancouver Island :—*Pinus contorta*, Doug. ; *Taxus baccata* [*brevifolia*, Doug.] ; *Abies Douglasii*, Lindl. ; *A. Menziesii*, Lamb ; *Thuja gigantea*, Nutt. ; *Cerasus mollis*, Doug. ; *Arbutus Menziesii*, Pursh [*laurifolia*, Doug ?] ; *Quercus Garryana*, Doug. [In a pamphlet recently sent to me by Dr. Robert Brown (Campster), of Edinburgh, he describes a second variety of Oak nearly allied to that mentioned, which, after Sir James Douglas, K.C.B., the late Governor, he calls *Q. Jacobi*. I may here mention that the oak, which is common in the north-east parts of Van-

* To the vast mineral riches of certain Territories south of the Boundary Line, I make no allusion, regarding these as entirely beyond my ken.

couver and the adjacent Islands, is not found in any part of the mainland of British Columbia.* The Oak (*Q. Garryana*) is common on the lower parts of the Columbia River somewhat remote from the ocean; ceasing abruptly at the Dalles of the Wascopum, above which there are none]. Species of *Acer*, *Betula*, *Alnus* and *Salix* are plentiful. Among the common shrubs are *Mahonia*, *Ceanothus*, *Nuttalia*, *Spiræa*, *Rosa*, *Ribes*, *Vaccinium*, *Salix*, *Gaultheria*, &c. Among the most conspicuous flowering plants in the early part of the season are several species of *Ranunculus*, of *Claytonia*, of *Potentilla*, and *Saxifraga*; *Plectritis congesta*, *Collonia gracilis*, *Collinsia violacea*, *Dodecatheon Meadia*, species of *Fritillaria* and *Trillium*, *Camassia esculenta* (*Scilla esculenta*, of Douglas). &c.

(b.) Along the lower Fraser: the several firs mentioned as found on the north-west coast, with also *Thuja gigantea* [but not *Cupressus thyoïdes*, which is peculiar to the coast vicinity, north of 49°, extending far into Alaska.] The circumference of a Douglas fir measured by Dr. Lyall was nearly thirty feet at five feet from the ground, and the length of a fallen tree measured, 250 feet, but neither an extraordinary specimen. [The height frequently exceeds 300 feet.] Circumference of a *Thuja* measured 26 feet 9 inches, at six feet from the ground; estimated height 250 feet [frequently exceeds this]. Interspersed among the trees mentioned are specimens of *Acer macrophyllum*, Pursh [*Platanus acerifolia*, of Douglas ?] sometimes attaining a height estimated at 150 feet—circumference of one measured twenty feet. Along with these the Vine-leaved Maple, *Acer circinatum*, Pursh; Dog-wood (*Cornus Nuttalii*); *Alnus viridis*, &c.; *Betula occidentalis*, Hooker, and *Populus balsamifera* of large size. [To these I may add that the White Pine (*P. strobus*), of magnificent dimensions, is common towards the summits of the southern portion of the Coast Range, and is found also, but of smaller size and more rarely, in the mountains of Vancouver Island. I have also noticed it in abundance and of fine size on the Cascade Range, about the skirts of Mount Rainier]. The under-shrubs consist chiefly of the fol-

* I noticed about a score of small trees in the portages above Yale on the Fraser River, as far back as 1847; but it is questionable if any one of these now remains.

lowing: *Mahonia*, two species; *Acer glabrum; Spiræa*, several species; "Sallal" (*Gaultheria shallon*, of Pursh); *Rubus* and *Ribes*, several species; *Lonicera*, two species; *Viburnum opulus; Vaccinium*, several species; *Panax horridus*. [By this last I conceive to be meant the *Bois piquant*, or "Prickly ash," a species of *Aralia* (*?*) Common in the damp vallies of the north-west coast, and re-appearing near the heads of Peace River and elsewhere along the verge of the Rocky Mountains.]

(c.). On the Cascade Range: *Abies amabilis*, Doug. [also found on the lower lands]; *A. grandis; Picea nobilis*, Don. [balsamea, Doug. ?], &c. [In this section are alse noticeable a fine red-flowering *Rhododendron*, (*macrophyllum* of Don.); two varieties of *Menziesia* (often mistaken for Heath); and among the numerous cyperaceous plants and Equisetæ the American Hellebore (*Veratrum viride*) is very common.]

(d.) [Approaching the Columbia River: As the valleys assume the Prairie character *Pinus ponderosa* and *Larix occidentalis* become common, as already mentioned (Supra). Dr. Lyall remarks: "The vegetation here is of a very different character "from that on the other side of the Cascade Mountains, and "bears indications of much drier climate. A good many of the "plants found in this region are strictly local in their distribu-"tion. Some of the orders such as *Ranunculaceæ*, *Vacciniaceæ*; "*Liliaceæ*, &c., of which species are so plentiful in the first "region, have here comparatively few representatives; whilst "others, such as *Leguminoseæ*, *Onagraceæ*, *Polemoniaceæ*, &c. "are more common in this district and give a character to the "vegetation."

I may mention cursorily that the Dwarf Sunflower (*Helianthus petriolaris*, Nutt.), here very common and characteristic, extends into British Columbia, as far nearly as Alexandria, the natives gathering its seed, and also preparing its root for food. The Flat-leaved Cactus, (*Opuntia Missouriensis*) too, extends to a point some miles above Alexandria, and downwards along the Fraser as far back as the Forks of the Thompson. It is also found in small patches on dry knolls on certain islands in the Gulf of Georgia; but not elsewhere in the northern section except, as before mentioned, on Peace River, near Dunvegan, where it was noticed by Mr. Macoun.]

Distribution of the more prominent Quadrupeds, &c. —Bison (*Bos Americanus*): plains of the Missouri, and of the Saskatchewan as low down as Carlton. Formerly abounded on the Peace River plains, but now rare and confined to the outskirts. Not found in British Columbia, save perhaps casually in parts of the Rocky Mountain frontier, nor on the Columbia River. Formerly used to descend the Snake River as far as Boisée River, and sometimes even lower. Will soon be all destroyed I fear. Caribou or Rein-deer (*Cervus tarandus*); the larger variety or "Rocky Mountain Rein-deer"; found in all the mountainous parts of the interior down to a certain latitude. Along the Rocky Mountains this limit I judge to be about lat. 49°; on the North-West Coast Range probably about 51°. The smaller variety, classed by Richardson as the Rein-deer of the Barren Grounds, is confined to the Arctic watershed during its northward migration (March to the beginning of November); frequenting the country around Hudson's Bay, &c., during the remainder of the year. The Moose or Elk (*C. alces*) is found generally throughout the northern parts of the country, except the Barren Grounds, and the immediate sea-board of Hudson's Bay, &c.; on the Pacific watershed along the verge of the Rocky Mountains as low as about 49°; on the upper Fraser, and as low down sometimes, but very rarely, as Fort George. The Chevreuil or Virginian deer is found along the Saskatchewan, but not in the mountainous parts, nor on the north-west coast, where the "Black Tail," (*C. macrotis*) is abundant. The last is not found on the Fraser higher than Fort George. The Red-deer or Biche (generally, but of course erroneously called "the Elk") is found in large herds over a wide extent of country. A large variety of *C. Elaphus*, it is classed as *C. Canadensis*, or the Wapiti. It is common along the Saskatchewan, Peace River, &c., and was so formerly upon the middle Fraser, but is now rarely, if ever, seen there. On Vancouver Island and the adjacent mainland very numerous. It is questionable whether there be any specific difference between these and those of the prairies. Bears, Black and Brown, (*Ursus Americanus*); generally throughout the country, except the immediate Arctic shores, where the Polar Bear appears. Grizzly Bear (*U. ferox*); plains of the Saskatchewan, &c., southwards; along the Rocky Mountains and in most parts of British Columbia, except Vancouver Island, and the north-west coast. Musk

Ox (*Ovibos Moschatus*) ; barren grounds of the Arctic Ocean. Probably frequents a portion of the Arctic slope of Alaska. Not found elsewhere. Lynx of two varieties, the spotted and the grey ; the former confined to the lower country, the latter to the interior. Racoon (*Procyon lotor*) ; east of the Rocky Mountains, as far north as Manitoba ; west-coast as high up as about 51°. Mountain Goat (*Aplocerus montanus*) ; Precipitous parts of the Rocky Mountains, coast range, &c., and north-west coast ; not found east of the Mackenzie.* Mountain Sheep or Big-horn (*Ovis Montana*) ; along the slopes of the Rocky Mountains and their offsets. Marmot (*Arctomys*) ; several species, including the Rocky Mountain variety or "Siffleur" (*A. pruinosus*, Rich'n.) found in the Rocky Mountains, the Cascade Range and North-West Coast Range. A *black* variety appears to be found about the heads of the Rivière aux Liards, which I have not noticed elsewhere. Foxes, Red, Black, Cross, &c., are very generally found except on the north-west coast, which, owing probably to the humidity of the climate, they do not appear to frequent. The Arctic or White Fox (*Vulpes lagopus*) is confined to the Arctic regions and the shores of Hudson's Bay. [The Arctic Hare (*Lepus variabilis*) appears throughout the interior of the mainland, north of 49°, in moderately elevated positions ; periodically in excessive numbers. A large variety, more resembling the European Hare, frequents the arid plains of the Columbia, &c.] The Marten (*Mustela martes*, Rich'n.), the Pekan or Fisher, and others of the same family, throughout the woodland regions. The Common Beaver (*Fiber Americanus*) and the Musquash (*Fiber zibethicus*, Rich'n) generally distributed, except in the Barren Grounds and other similar Arctic positions. The Carcajou or Wolverine, (*Gulo luscus*, Cuv.) : very generally north of 49°. Wolves of divers varieties, Grey, Black, &c., generally throughout ; a pure white variety being found on the "Barren Grounds." The Common Otter (*Lutra Canadensis*) throughout. The Sea Otter (*Enhydra marina*) is found only on the Pacific Coast, from California up to the Kodiak, &c., in which tract the Hair Seal and a large variety of other *Phocidæ*, are also common ; especially in Alaska, where the chase of the Fur-Seal has long been systematically regulated.

* These are the animals described to Mackenzie by the Indians as "White Buffaloes."

Birds.—Exclusively of innumerable migratory birds, from the Swan and the Eagle down to the Humming Bird (the last confined to the Pacific slope, where it is found as high, at least, as 54° 26′, and doubtless beyond), the following permanent residents of utility may be noticed: Ruffed Grouse (*Bonasa umbellus*, Linn.); almost everywhere near streams, &c. Dusky Grouse (*Tetras obscurus*, Say), dry stony ridges, Vancouver Island, and mainland interior north of about 49° on western slope, as high as the vicinity of Alexandria. Spotted Grouse or "Spruce Partridge" (*T. Canadensis*, Linn.); dry uplands within certain limits on both sides of the Rocky Mountains. White Grouse or Ptarmigan (*Lagopus albus*); mountainous parts, Vancouver Island and northern mainland; very numerous throughout the Arctic slopes and Hudson's Bay. Sharp-tailed Grouse (*Pediœcetes phasianellus*, Linn.); throughout the great Prairies; in the prairie-valleys of British Columbia, as high as the vicinity of Alexandria; and on the Plains of Peace River. Cock of the Plains or "Sage-Cock," (*Centrocercus urophasianus*, Bon.); borders of the Columbia River, from above Okinâgan to the Dalles of Wasco, and throughout the Wormwood deserts.

Fish.—Trout of many different kinds; varieties of Carp and other *Cyprinidæ*; the Methy or Loche; and many others, including that Prince of fresh-water fishes the White-fish (*Coregonus*), are general distributed. The last named (peculiarly a northern fish) appears to be almost universal in the boreal regions, even the lakes of the dreary "Barren Grounds" having their share. Westward of the Rocky Mountains, they are found as low, at least, as lat. 52°; and probably even somewhat south of that limit. Two varieties of Sturgeon are found, one (*Acipenser Sturio ?*) in the waters of Lake Winnipeg, the other (*A. transmontanus* of Richards) a fish of enormous dimensions, in the Columbia and the Fraser. Salmon, chiefly of large size, and of many varieties, ascend all the principal streams between the Sacramento and Yukon, including both those rivers; and probably several of the streams discharging into the Arctic Ocean; but as before remarked they do not frequent either the Mackenzie or the Saskatchewan; nor indeed any of the rivers communicating with the Hudson's Bay. The Pike (*Esox lucius*), common to the eastern waters, is unknown on the western watershed. To the above list may be added, as frequenting the waters of Manitoba, the Cat-Fish, the Sun-fish, and divers others, some of which are found elsewhere.

INDIANS.—The Chipewyan race, who for convenience sake are now classed as the "Dinnee" or "Tinneh" tribes, occupy as will be seen a very extensive tract. They have evidently been great wanderers; for to them the isolated sept of the Sarcees of the Saskatchewan owes its origin; and a similar offset, the *Klatskanai* (now extinct), not very long ago inhabited the highlands beyond the mouth of the Columbia River, while traces of the language appear even farther south. *Dinnee* means literally *a man*, but is sometimes applied in the plural sense, as *Abahto-dinnee*, the Mountain men, &c.; and Sir A Mackenzie's interpreters, who were from Peace River, so applied it, calling *Nascud-dinnee* those whom we now know as the *Nasc-otin*, i. e. *People* of the *Nas-accôh* (Mackenzie's "West-road River.") Generally, however, the term is pluralized by changing it, eastward of the Rocky Mountains, into *hânie*, westward into *otin*, as *Sik-hanie* (or rather *Tsack-hânie*) People of the stones or rocks, &c *Nasc-otin* (as above): *Chilo-otin*, People of the *Chil-accoh* (River), &c. In the Alaska section this affix is changed into *Koochin*, having the same obvious signification. The Tâh-Cully-(otin) Branch, i. e. "People of the deep" (waters being probably understood) inhabit the upper waters of the Fraser, bounded southward by the *Shewhapmuch* (ch guttural) or *Sacliss* connexion (Atnah or "chin" of Mackenzie). Eastward of the Rocky Mountains the Chipewyans are bounded on the east by the Crees, who pass round the south end of Lake Winnipeg, and continue round the circuit of Hudson's Bay and through Labrador, to Hudson's Strait. Adjoining the Crees, and following along the upper Lakes and down the Ottawa River, &c., are the Algonquins or Sauteux, called also Ojibways or Chippeways. These are merely a branch of the Crees, and talk a dialect of the same language. The Assineboines are a branch of the Nadowasis or Sioux, and bound the Crees on the south along the course of the upper north Saskatchewan; succeeded on the west by the Sarcees, the small isolated tribe already noticed. A few families of Assineboines, abandoning the Prairie habit of the rest, frequent the heads of the Athabasca, among the "strong woods" (whence their distinctive appellation) and are now intercepted by the neighbouring tribes from the remainder of their race. The Black-feet, divided into several septs, as Gros Ventres, Blood Indians, &c., inhabit the prairie tract along the heads of the Saskatchewan and Missouri towards the border of the Sioux.

Opposite to them, west of the Rocky Mountains, in a small angle at the heads of the branch of the Columbia, are the Koutananais, a small tribe, numbering in 1848 in all 829 souls. These are isolated from all the surrounding races, and I have never been able to trace their connexion. Adjoining them are the Sacliss (called by the Black-feet "Flatheads") who with their congeners the Shewhapmuch extend nearly to Alexandria, meeting the Tâh-Cully branch of the Tinneh race as already mentioned. To the Shewhapmuch the Tah-Cully apply the same name of "Atnah" (= Stranger Race); to their neighbors wesward Atnah-yore. Mackenzie who descended the Fraser no lower than the Tâh-Cully frontier, and had with him no interpreters through whom to communicate freely with the few men of the lower nation whom he there met. He was thus led to adopt the term "Atnah" as the true name of the tribe—adding, however, the alternative "Chin" which has in reality no existence. The late Mr. Geo. Gibbs, shortly before his death, wrote to enquire the origin of the latter name. To this enquiry I had no opportunity of replying; and may now state that I believe it to have arisen from misapprehension of the meaning of the Indians while referring to the principal village, or at least that in the most prominent position, at the confluence of the Thompson with the Fraser. This is called *Thlik-um-cheen* (or-chin), the first two syllables very rapidly pronounced, and the last strongly dwelt upon. To this village the natives, both above and below, are fond of referring, apparently with some pride, as the chief seat of their section of the general tribe: and the conspicuous syllable dwelling on the ear of Mackenzie, led him, I imagine, to suppose it was the name given by themselves to their nation. I notice that the late Mr. Simon Fraser, who with Mr. John Stuart first descended the river, now named after the former, in 1808, and a M.S. copy of whose Journal is now before me, was partially misled in the same probable way. He gives the name of the village (but not as of the people) as *Cum-chin*. The whole ordinary nomenclature of Indian tribes, however, such connexion invariably giving a different, and derisive name, originating in some imputed or imagined characteristic (e. g. Blackfoot, Flathead, Slave, &c.), requires to be received with much caution. For this reason, and to avoid the endless confusion of names, I have along the north-west coast reduced them in the map as much as

possible to classes, on the principle of the "Tinneh." Thus along Paget Sound,&c., I comprise the numerous *homish*, *âmish*, and *wâmish*, all modifications of the same general affix, under one head as the *âmish* tribes; and along the west coast of Vancouver's Island, and the adjacent coast southward, the *âht* tribes, this being the general affix, *Nootk-âht*, *Clayo-qu-âht*, &c. Northward of these the *Hâi-dah* occupy Queen Charlotte's Islands and the Prince of Wales portion of the Archipelago. On the mainland north of Vancouver's Island and in the Islands of Milbank Sound and connected waters, is the Hâiltza connexion; succeeded northward by the *Chimseyan* tribes, who occupy as far as Observatory Inlet, near the southern line of Alaska Territory. Thence the *Thlinkitt* connexion to beyond the Tâh-Co River, who are succeeded by the tribe called by the Russians "Kaliuches"; and finally, beyond Cook's Inlet, the Esquimaux.

NOTES ON A COLLECTION OF GEOLOGICAL SPECIMENS.

Collected by William Macleay, Esq., F.L.S., *President of the New South Wales Linnean Society, Sydney, from the coast of New Guinea, Cape York, and neighbouring islands, by* C. S. Wilkinson, *Government Geologist.* (*Read before the Linnean Society, Sydney, 28th February*, 1876.)

I have lately examined a small collection of geological specimens, brought from the coast of New Guinea by the President of of this Society, Mr. William Macleay, and which were collected by him when on his recent tour of exploration in the Chevert.

These specimens consist of—

1. Quartz porphyry (Palæozoic), from Cape York, found underlying beds of Tertiary ferruginous sandstone.

2. Vesicular basalt and brecciated volcanic tufa (Upper Tertiary), from Darnley Island.

3. Small concretions of limonite, with polished-looking surfaces, dredged up off the coast of New Guinea.

4. Specimens of chalcedony and flint, from Hall's Sound.

5. Oolite limestone (Tertiary), very friable, from Bramble Cay.

6. Yellow calcareous (Tertiary) clay, from Katau River.

7. Yellow and blue calcareous clays (Tertiary), from Yule Island and Hall's Sound.

It is with reference more particularly to the fossiliferous clays that I would offer a few remarks.

These clays, as indicated by the fossils contained in them, belong to the Lower Miocene Tertiary period.

So far as I am aware, this is the first notice of such fossils having been discovered in New Guinea ; and this discovery of Mr. Macleay's is the more interesting inasmuch as the Miocene *marine* beds, which occupy a considerable area in Victoria and South Australia, have nowhere been found on the eastern coast of Australia, north of the Victorian border—Cape Howe. Referring to this fact the Rev. W. B. Clarke says that, " throughout the whole of Eastern Australia, including New South Wales and Queensland, no Tertiary *marine* deposits have been discovered."

The comparison of this Miocene fauna from a locality so near the equator, with that from higher latitudes, will be important work for a palæontologist.

Professor McCoy has already gone far to prove from the comparison of certain Miocene fossils, that the fauna of the Older Tertiary period in Australia was not so restricted in its geographical range as it now is, but was then closely related generically, and even specifically, to that of many parts of Europe and America. And I think that, perhaps, even the few fossils now before us may afford some additional evidence in confirmation of the views of that eminent palæontologist.

The Miocene clay beds of New Guinea, judging from the specimens collected by Mr. Macleay, are exactly similar in lithological character to the Lower Miocene beds near Geelong, and on the Cape Otway coast in Victoria.

The fossils from Hall's Sound are unfortunately not in a good state of preservation, being mostly imperfect casts ; but amongst them appear to be the following genera :—

Voluta macroptera, a small specimen ; *Voluta anti-cingulata*, *Ostrea*, *Cytherœa*, *Crassatella ?* *Pecten*, *Turritella*, *Natica*, *Triton ?* *Dolium ?* *Astarte*, *Corbula*, *Leda*, *Venus*, *Cyprœa*, 2 *Echinoderms.*

Most of the above I have found in the Victorian beds, and two of them have been figured and described by Professor M'Coy in his *Decade No.* 1 of the *Palæontology of Victoria.*

The small specimen of calcareous clay from the Katau River on the west side of the Gulf of Papua contains only a few broken fragments of shells ; but it appears to be of the same formation as the clay beds of Hall's Sound or Yule Island.

The oolitic limestone of Bramble Cay I believe to be also of the upper beds of this Miocene formation.

Mr. Macleay, in his letter to the *Sydney Morning Herald* of October 11, 1875, describes the formation of Yule Island as a sedimentary rock, nearly horizontal on the sea face, but with a great dip inwards. The rock itself is calcareous, and composed of corals, shells, echini, &c.—in fact a concrete of fossils resembling the coral rag of Oxford. Mr. D'Albertis also gives a similar description of the formation of Yule Island, and mentions the occurrence of basaltic trap in the valleys, and that the higher portions of the hills, which attain a height of 700 or 800 feet above sea level, are composed of coralline limestone. It is worthy of remark that in Victoria the Miocene strata occur in a similar manner—yellow and blue calcareous clays full of fossil shells, overlaid by thick beds of coralline limestone consisting of an aggregate of comminuted fragments of corals, shells and echinoderms.

The discovery of these Miocene beds on the southern coast of New Guinea is one of considerable importance. Their occurrence, I believe, suggests the former land-connection of New Guinea with the Australian continent, and this belief is further borne out by the fact of the shallowness of the intervening sea. I am not aware that any Miocene rocks have yet been identified as such on the northern coast of the Cape York Peninsula ; but it is not improbable that the ferruginous sandstone described by Mr. Macleay as overlying the porphyritic granite at Cape York, and perhaps other Tertiary deposits which may occur in that locality, may be correlated with the Miocene beds on the opposite coast of New Guinea.

Wallace, referring to this subject in his very interesting and valuable work, *The Malay Archipelago*, says :—" It is interesting to observe among the islands themselves how a shallow sea always intimates a recent land-connection." . . . " We find that all the islands from Celebes and Lombock eastward exhibit

almost as close a resemblance to Australia and New Guinea as the Western Islands do to Asia." And again—" Australia, with its dry winds, its open plains, its stony deserts, and its temperate climate, produces birds and quadrupeds which are closely related to those inhabiting the hot damp luxuriant forests which everywhere clothe the plains and mountains of New Guinea."

Baron von Mueller's remarks on some of the Papuan plants collected by Mr. Macleay are also evidence in favour of the former land-connection of New Guinea with Australia, so that our geological evidence is supported by that of zoology and botany.

From geological data it is believed that this continent has not been submerged to any great extent, since the Lower Pliocene period ; and we know that it has risen a little since the Upper Pliocene epoch, at least in Victoria, for the lava flows of that age, now forming the Werribee Plains, were *submarine* flows. And Mr. Daintree, formerly Government Geologist of Queensland, shows, in his pamphlet on the *Geology of Queensland*, that little upheaval of this portion of Australia has taken place since the volcanic outbursts of a late Tertiary epoch. Now, it is in the Upper Pliocene or Pleistocene deposits that are found the remains of the gigantic marsupials—*Diprotodon*, *Macropus*, *Titanotherium*, and others ; and, as their allied representatives now occupy both Australia and New Guinea, it is not improbable that those gigantic animals whose bones are found in Northern Queensland, also roamed in both those countries. And further, as the luxuriant vegetation and climatic conditions which we suppose to be favourable for the support of those immense marsupials still exist in New Guinea, is it rash to conjecture that some of these large creatures may be living there at the present time ? Further researches may prove this.

I will conclude with the following very apposite extract from Wallace's *Malay Archipelago* :—

" From this outline of the subject, it will be evident how important an adjunct natural history is to geology ; not only in interpreting the fragments of extinct animals found in the earth's crust but in determining past changes in the surface which have no geological record. It is certainly a wonderful and unexpected fact, that an accurate knowledge of the distribution of birds and insects should enable us to map out lands and continents which disappeared beneath the ocean long before the earliest traditions

of the human race. Wherever the geologist can explore the earth's surface, he can read much of its past history, and can determine approximately its latest movements above and below sea-level; but wherever oceans and seas now extend, he can do nothing but speculate on the very limited data afforded by the depth of the waters. Here the naturalist steps in, and enables him to fill up this great gap in the past history of the earth."

THE WINTERS OF 1874–75 and 1875–76.

By C. H. McLeod, Bac. App. Sc.

The saying "it's all in a bag and must come out," so frequently applied to the weather, is in a certain sense true, but we must not be in too great a hurry for the bag to empty itself. This *meteoric sack*, so to speak, disgorges its contents in an intermittent sort of fashion—now we have heat above the normal, and again an excess of cold. The velocity of discharge varies throughout a day, varies continually; the *means* of the elements for a day exceed or fall below those on either side of it, so also the means for a year show a marked difference from that preceding or following it, and the average temperature or rainfall of one season often bears but little resemblance to the same period in another year. On the other hand, given a period of from five to ten years, it is found that the mean of any element for that time does not differ materially from those derived from any other similar period. It therefore takes several years for the truth of the saying above quoted to be verified, and when after continuous observation of an element for the required time, an average or mean for that element is determined, the normal proper to the place and any given time is said to be known; and this is the average of what we have chosen to term velocity of discharge—to be so determined for each and all of the meteorological elements.

How much one of our seasons may differ from another has been most markedly illustrated during the past two winters and it is to that we propose calling attention at present.

The following table derived from the observations recorded at the McGill College Observatory, institutes a comparison between the periods we are considering.

Winter.	Mean Temperature of Dec.	Mean Temperature of Jan.	Mean Temperature of Feb.	Mean Temperature of the season.
1874—75	14.60	5.44	9.02	9.69
1875—76	16.73	17.73	14.57	16.34

It will be observed that between the *means* for the two seasons there is the large difference of nearly seven degrees, and that January of 1876 was warmer than the same month in 1875 by more than twelve degrees, that is, on the average each day of the month was more than twelve degrees warmer than the corresponding day in the preceding year.

The primary cause of this most remarkable discrepancy is, at present, beyond us to discover; but if it affords any satisfaction to connect it with facts which themselves require explanation we may state that in the winter of 75–76 winds blowing from the south-west to south-east exceeded in duration those from the same quarter in the winter of 74–75 by about fifty per cent. Or expressed otherwise, the time during which winds in each season blew between these directions bears about the same relation between themselves as does the average temperature for the seasons expressed in degrees Fahrenheit to one another.

The connection is evident, and it is of course also true, that there was during the winter of 1874–75 a great excess of winds blowing from the cold regions to the north and north west.

In connection with the table given below, which shows the total precipitation in each month and season, it should be stated that in 1875–76, (taking ten inches of snow as equal to one inch of water) 79.1 inches only, fell as snow, the remaining 3.67 inches being rain; whereas in 1874–75 the rainfall only amounted to .48 of an inch.

Winter.	December.	January.	February.	Season.
1874—75	2.20 ins.	3.50 ins.	1.71 ins.	7.41 ins.
1875—76	3.10 ins.	4.61 ins.	3.87 ins.	11.58 ins.

The predominance of rainfall during last winter is a natural result of the mildness of the season, and there is apparently also a close connection between the excessive precipitation and increased temperature.

The two seasons contrast very strongly in other respects beyond a divergence in temperature and rain or snowfall. For while the winter of 1874–75 was characterized by unusual meteoric uniformity last winter was remarkable for its extreme; the barometer having ranged from 28.766 to 30.989 in the latter season, against from 29.303 to 30.753 in the former; and the wind's velocity having attained a maximum of 60 miles per hour, or ten miles greater than any previous record. The thermometer, too, showed an excessive range, although the minimum is slightly above that recorded in 1874–75, when it reach 24 below zero, while the maximum recorded was 43.5, giving a range of only 67.5 degrees against 77.5 with a maximum of 54 degrees last winter.

NOTE ON THE PHOSPHATES OF THE LAURENTIAN AND CAMBRIAN ROCKS OF CANADA.

By J. W. Dawson, LL.D., F.R.S., F.G.S.

The extent and distribution of the deposits of apatite contained in the Laurentian of Canada and in the succeeding Palæozoic formations, have not escaped the notice of our Geological Survey, and have been referred to in some detail in Reports of Mr. Vennor, Mr. Richardson, and others, as well as in the General Report prepared by Sir W. E. Logan in 1863. Some attention has also been given, more especially by Dr. Sterry Hunt, to the question of the probable origin of these deposits.* My own attention has been directed to the subject by its close connexion with the discussions concerning *Eozoon;* and I have therefore embraced such opportunities as offered to visit the localities in which phosphates occur, and to examine their relations and structure. I would now present some facts and conclusions respecting these minerals, more especially in their relation to the life of the

* Geology of Canada, 1863; Chemical and Geological Essays, 1875.

Laurentian period, but which may also be of interest to British geologists in connexion with the facts recently published in the 'Journal' of this Society in relation to the similar deposits found in the Cambrian and Silurian of Wales.*

In the Lower Silurian and Cambrian rocks of Canada, phosphatic deposits occur in many localities, though apparently not of sufficient extent to compete successfully for commercial purposes with the rich Laurentian beds and veins of crystalline apatite.

In the Chazy formation, at Alumette Island, and also at Grenville, Hawkesbury, and Lochiel, dark-coloured phosphatic nodules abound. They hold fragments of *Lingulæ*, which also occur in the containing beds. They also contain grains of sand, and, when heated, emit an ammoniacal odour. They are regarded by Sir W. Logan and Dr. Hunt as coprolitic, and are said to consist of "a paste of comminuted fragments of *Lingulæ*, evidently the food of the animals from which the coprolites were derived." † It has also been suggested that these animals may have been some of the larger species of Trilobites. In the same formation, at some of the above places, phosphatic matter is seen to fill the moulds of shells of *Pleurotomaria* and *Holopea*.

In the Graptolite shales of the Quebec group, at Point Levis, similar nodules occur; and they are found at Rivière Ouelle, Kamouraska, and elsewhere on the Lower St. Lawrence, in limestones and limestone conglomerates of the Lower Potsdam group which is probably only a little above the horizon of the Menevian or Acadian series. In these beds there are also small phosphatic tubes with thick walls, which have been compared to the supposed worm tubes of the genus *Serpulites*.‡

The Acadian or Menevian group, as developed near St. John, New Brunswick, contains layers of calcareous sandstone blackened with phosphatic matter, which can be seen, under the lens, to consist entirely of shells of *Lingulæ*, often entire, and lying close together in the plane of the deposit, of which in some thin layers they appear to constitute the principal part.§ Mr. Matthew informs me that these layers belong to the upper part of the forma-

* Davies & Hicks in Quart. Journ. Geol. Soc., August, 1875.

† Geology of Canada, p. 125.

‡ Geology of Canada, p. 259; Richardson's Report, 1869.

§ Bailey and Matthew, "Geology of New Brunswick," Geol. Survey Reports.

tion, and that the layers crowded with *Lingulæ* are thin, none of them exceeding two inches in thickness; but he thinks that the dark colour of some of the associated sandstones and shales is due to comminuted *Lingulæ*.

At Kamouraska, where I have studied these deposits, the ordinary phosphatic nodules are of a black colour, appearing brown with blue spots when examined in thin slices with transmitted light. They are of rounded forms, having a glazed but somewhat pitted surface—and are very hard and compact, breaking with glistening surfaces. They occur in thin bands of compact or brecciated limestone, which are very sparingly fossiliferous, holding only a few shells of *Hyolithes* and certain *Scolithus*-like cylindrical markings. In some of these beds siliceous pebbles occur with the nodules, rendering it possible that the latter may have been derived from the disintegration of older beds; but their forms show that they are not themselves pebbles. Phosphatic nodules also occur sparingly in the thick beds of limestone conglomerate which are characteristic of this formation; they are found both in the included fragments of limestone and in the paste. The conglomerates contain large slabs and boulders of limestone rich in *Trilobites* and *Hyolithes;* but in these I have not observed phosphatic nodules.

In some of the limestones the phosphatic bodies present a very different appearance, first noticed by Richardson at Rivière Ouelle, and of which I have found numerous examples at Kamouraska. A specimen now before me is a portion of a band of grey limestone, about four inches in thickness, and imbedded in dark red or purple shale. It is filled with irregular, black, thick-walled cylindrical tubes, and fragments of such tubes, along with phosphatic nodules—the whole crushed together confusedly, and constituting half of the mass of the rock. The tubes are of various diameters, from a quarter of an inch downward; and the colour and texture of their walls are similar to those of the ordinary phosphatic nodules.

Under the microscope the nodules and the walls of the tubes show no organic structure or lamination, but appear to consist of a finely granular paste holding a few grains of sand, a few small fragments of shells without apparent structure, and some small spicular bodies or minute setæ. The general colour by transmitted light is brown; but irregular spots show a bright blue colour, due probably to the presence of phosphate of iron (vivi-

anite). The enclosing limestone and the filling of the tubes present a coarser texture, and appear made up of fragments of limestone and broken shells, with some dark-coloured fibres, probably portions of Zoophytes. Scattered through the matrix there are also small fragments, invisible to the naked eye, of brown and blue phosphatic matter.

One of the nodules from Alumette gave to Dr. Hunt 36·38 of calcic phosphate; one from Hawkesbury 44·70; another from Rivière Ouelle 40·34; and a tube from the same place 67·53.* A specimen from Kamouraska, analyzed by Dr. Harrington, gave 55·65 per cent. One of the richest pieces of the linguliferous sandstone from St. John yielded to the same chemist 30·82 of calcic phosphate and 32·44 of insoluble siliceous sand, the remainder being chiefly carbonate of lime.

Various opinions may be entertained as to the origin of these phosphatic bodies; but the weight of evidence inclines to the view originally put forward by Dr. Hunt†, that the nodules are coprolitic; and I would extend this conclusion with some little modification to the tubes as well. The forms, both of the tubes and nodules, and the nature of the matrix, seem to exclude the idea that they are simply concretionary, though they may in some cases have been modified by concretionary action. There are in the same beds little piles of worm-castings of much smaller diameter than the tubes, and less phosphatic; and there are also *Scolithus*-like burrows penetrating some of the limestones, and lined with thin coatings of phosphatic matter similar to that of the tubes. Further, the association of similar nodules in the Chazy limestone with comminuted *Lingulæ*, as already stated, is a strongly confirmatory fact.

The tubes are of unusual form when regarded as coprolitic; but they may have been moulded on the sides of the burrows of marine worms; or these creatures may have constructed their tubes of this material, either consisting of their own excreta or of that of other animals lying on the sea-bottom. In any case, the food of the animals producing such excreta must have been very rich in solid phosphates, and these animals must have abounded on the sea-bottoms on which the remains have accumulated. It is also evident that such phosphatic dejections might either retain their original forms, or be aggregated into nodular masses, or shaped into tubes or burrows of Annelids, or,

* Geology of Canada, p. 461. † Ibid.

if accumulated in mass, might form more or less continuous beds.

The food of the animals producing such coprolites can scarcely have been vegetable; for though marine plants collect and contain phosphates, the quantity in these is very minute, and usually not more than that required by the animals feeding on them.

We must therefore look to the animal kingdom for such highly phosphatic food. Here we find that a large proportion of the animals inhabiting the primordial seas employed calcic phosphate in the construction of their hard parts. Dr. Hunt has shown that the shells of *Lingula* and some of its allies are composed of calcic phosphate: and he has found the same to be the case with certain Pteropods, as *Conularia*, and with the supposed worm-tubes called *Serpulites*, which, however, are very different in structure from the tubes above referred to.

It has long been known that the crusts of modern Crustaceans contain a notable percentage of calcic phosphate; and Hicks and Hudleston have shown that this is the case also with the Cambrian Trilobites. Dr. Harrington has kindly verified this for me by analyzing a specimen of highly trilobitic limestone from the Lower Potsdam formation at St. Simon, in which the crusts of these animals are so well preserved that they show their minutely tubulated structure in great perfection under the microscope. He finds the percentage of calcic phosphate due to these crusts to be 1·49 per cent. of the whole mass. It is to be observed, however, that the crusts of Trilobites must have consisted very largely of chitinous matter, which, in some cases, still exist in them in a carbonized state. A crust of the modern *Limulus*, or King Crab, which I had supposed might resemble in this respect that of the Trilobites, was analyzed also by Dr. Harrington. It belonged to a half grown individual, measuring 5·25 inches across, and was found to contain only 1·845 per cent. of ashes, and of this only 1·51 per cent. of calcic phosphate. The crusts of some Trilobites may have contained as large a proportion of organic matter; but they would seem to have been richer in phosphates. Next to *Lingulæ* and Trilobites, the most abundant fossils in the formations containing the phosphatic nodules are the shells of the genus *Hyolithes*, of which several species have been described by Mr. Billings*. Dr. Harrington has

* Canadian Naturalist, Dec. 1871.

ascertained that these shells also contain calcic phosphate in considerable proportion. The proportion of this substance in a shell not quite freed from matrix was 2·09 per cent. These shells have usually been regarded as Pteropods; but I find that the Canadian primordial species show a structure very different from that of this group. They are much thicker than the shells of proper Pteropods; and the outer layer of shell is perforated with round pores, which in one species are arranged in vertical rows. The inner layer, which is usually very thin, is imperforate. In one species (I believe, the *H. americanus* of Billings), the perforations resemble in size and appearance those in the shells of *Terebratulæ*. In another species (*H. micans* probably) they are very fine and close together, as in some shells of tubicolous worms. I am therefore disposed to regard the claim of these shells to the rank of Pteropods as very doubtful. They may be tubicolous worms, or even some peculiar and abnormal type of Brachiopod. In connection with this last view, it may be remarked that the operculum of some of the species much resembles a valve of a Brachiopod, and that the conical tube is in some of them not a much greater exaggeration of the ventral valve of one of these shells than the peculiar *Calceola* of the Upper Silurian and Devonian, which has been regarded by some palæontologists as a true Brachiopod. I have not, however, had any opportunity of comparing the intimate structure of *Calceola* with that of these shells. Shells of *Hyolithes* occur in the Lower Potsdam in the same beds with the phosphatic nodules; and in one of these Mr. Weston has found a series of conical shells of *Hyolithes* pressed one within another, as if they had passed in an entire state through the intestine of the animal which produced the coprolite.

Inasmuch, then, as some of the most common invertebrates of the Cambrian seas secreted phosphatic shells, it is not more incredible that carnivorous animals feeding on them should produce phosphatic coprolites than that this should occur in the case of more modern animals feeding on fishes and other vertebrates.

We may now turn to the question as to the source of the abundant apatite of the Laurentian rocks. Were this diffused uniformly through the beds of this great system, or collected merely in fissure or segregation veins, it might be regarded as having no connexion with other than merely mineral causes of deposit. It appears, however, from the careful stratigraphical

explorations of the Canadian Survey, in the districts of Burgess and Elmsley, which are especially rich in apatite, that the mineral occurs largely in beds interstratified with the other members of the series, though deposits of the nature of veins likewise occur. It also appears that the principal beds are confined to certain horizons in the upper part of the Lower Laurentian, above the limestones containing *Eozoon*, though some less important deposits occur in lower positions. *

The principal apatite-bearing band of the Laurentian consists of beds of gneiss, limestone, and pyroxene-rock, and has a thickness of from 2600 to 3600 feet. It has been traced over a great extent of country west of the Ottawa river, and has also been recognized on the east side of that river as well. The mineral often forms compact beds with little foreign intermixture; and these sometimes attain a thickness of several feet, though it has been observed that their thickness is variable in tracing them along their outcorps. Several beds often lie near to each other in the same member of the series. Thin layers of apatite also occur in the lines of bedding of the pyroxene-rock. In other cases disseminated crystals are found throughout thick beds of limestone, sometimes, according to Dr. Hunt, amounting to two or three per cent. of the whole mass. Disseminated crystals also occur in some of the beds of magnetite, a mode of occurrence which, according to Dr. Hunt, has also been observed in Sweden and in New York in the Laurentian magnetites of those regions.

The veins of apatite fill narrow and usually irregular fissures; and the mineral is associated in these veins with calcite and with large crystals of mica. In one instance, at Ticonderoga, in New York, the apatite, instead of its usual crystalline condition, assumes the form of radiating and botryoidal masses, constituting the Eupyrchroite of Emmons. Since these veins are found principally in the same members of the series in which the beds occur, it is a fair inference that the former are a secondary formation, dependent on the original deposition of apatite in the latter, which must belong to the time when the gneisses and limestones were laid down as sediments and organic accumulations.

In all the localities in which I have been able to examine the Laurentian apatite, it presents a perfectly crystalline texture,

* Vennor's Reports, 1872–73 and 1873–74.

while the containing strata are highly metamorphosed; and this appears to be its general condition wherever it has been examined. Numerous slices of the more compact apatite of the beds have been prepared by Mr. Weston, of the Geological Survey; but, as might be expected, they show no trace of organic structure. All direct evidence for the organic origin of this substance is therefore still wanting. There are, however, certain considerations, based on its mode of occurrence, which may be considered to afford some indirect testimony.

If, with Hunt, we regard the iron ores of the Laurentian as organic in origin, the apatite which occurs in them may reasonably be supposed to be of the same character with the phosphatic matter which contaminates the fossiliferous iron ores of the Silurian and Devonian, and which is manifestly derived from the included organic remains.

If we consider the evidence of *Eozoon* sufficient to establish the organic origin, in part at least, of the Laurentian limestones, we may suppose the disseminated crystals of apatite to represent coprolitic masses or the débris of phosphatic shells and crusts, the structure of which may have been obliterated by concretionary action and metamorphism.

Such Silurian beds of compact and concretionary apatite (without structure, yet manifestly of organic origin) as that described by Mr. Davies in the 'Journal' of this Society, may be taken as fair representatives of the bedded apatite of the Laurentian. Further, the presence of graphite in association with the apatite in both cases may not be an accidental circumstance, but may depend in both on the association of carbonaceous organisms, whether vegetable or animal.

Again, the linguliferous sandstone of the Acadian group is a material which, by metamorphism, might readily afford a pyroxenite with layers of apatite like those which occur in the Laurentian.

The probability of the animal origin of the Laurentian apatite is perhaps further strengthened by the prevalence of animals with phosphatic crusts and skeletons in the Primordial age, giving a presumption that in the still earlier Laurentian a similar preference for phosphatic matter may have existed, and, perhaps, may have extended to still lower forms of life, just as the appropriation in more modern times of phosphate of lime by the higher animals for their bones seems to have been accompanied by a dimution of its use in animals of lower grade.

The Laurentian apatite pretty constantly contains a small percentage of calcium fluoride; and this salt also occurs in bones, more especially in certain fossil bones. This may in both cases be a chemical accident; but it supplies an additional coincidence.

In the lowest portions of the Lower Laurentian no organic remains have yet been detected; and these beds are also poor in phosphates. The horizon of special prevalence of *Eozoon* is the Grenville band of limestone, which, according to Sir William Logan's sections, is about 11,500 feet above the fundamental gneiss. It appears, from recent observations of Mr. Vennor and Mr. W. T. Morris, that the bed holding the Burgess *Eozoon* is on the same horizon with the limestone of Grenville. The phosphates are most abundant in the beds overlying this band. This gives a further presumption that the collection and separation of the apatite is due to some organic agency, and may indicate that animals having phosphatic skeletons first became abundant after the sea-bottom had been largely occupied by *Eozoon*.

I would not attach too great value to the above considerations; but, taken together, and in connection with the occurrence of apatite in the Cambrian and Silurian, they seem to afford at least a probability that the separation of the Laurentian phosphate from the sea-water, and its accumulation in particular beds, may have been due to the agency of marine life. Positive proof of this can be obtained only by the recognition of organic form and structure; and for this we can scarcely hope, unless we should be so fortunate as to find some portion of the Lower Laurentian series in a less altered condition than that in which it occurs in the apatite districts of Canada. Should such structures be found, however, it is not improbable that they may belong to forms of life almost as much lower than the *Lingulæ* and Trilobites of the Cambrian as these are inferior to the fishes and reptiles of the Mesozoic.—*From the Quarterly Journal of the Geological Society.*

NATURAL HISTORY SOCIETY.

PROCEEDINGS FOR THE SESSION 1875–76.

MONTHLY MEETINGS.

1st Monthly Meeting, held October 25th, 1875.

The Rec.-Secretary having read a letter in which the Messrs. Allan Bros. of Liverpool, undertook to convey to the Society a box of specimens presented by Lieut.-Col. Bulger, free of charge: It was moved by Prof. Darey, seconded by E. E. Shelton, and resolved:—"That the thanks of the Society be voted to the Messrs. Allan Bros. for their liberality in this matter."

A number of donations to the Library and Museum were announced and exhibited, and the thanks of the meeting were voted to each of the donors.

Dr. B. J. Harrington then read an obituary notice of the late Sir W. E. Logan. This will be found on pages 31–46 of the present volume.

Rev. Dr. De Sola, who occupied the chair in the absence of the President, having made some remarks on the great loss which the Society had sustained by the decease of one of its most eminent and oldest members: it was moved by Principal Dawson, seconded by G. L. Marler, and resolved unanimously: "That Dr. Harrington be requested to publish the obituary notice just read in the Proceedings of this Society in the *Canadian Naturalist*, as a testimony to the honour in which the Society, in common with all other friends of science in this country, holds the memory of Sir W. E. Logan, and that copies be sent in the name of the Society to his surviving relatives."

Dr. P. P. Carpenter made a communication "On the life and labours of the late Dr. John Edward Gray, of the British Museum, and of Prof. G. P. Deshayes, formerly of the Jardin des Plantes, Paris," after which the meeting closed.

2nd Monthly Meeting, held November 29th, 1875.

After the transaction of the usual routine business, a discussion ensued on the question of the proposed union with the Fraser Institute; and the previous correspondence on the sub-

ject, and conditions suggested, having been read, the President, A. R. C. Selwyn, F.R.S., &c., on behalf of the Committee appointed to confer with the Governors of the Fraser Institute, asked authority from the Society to carry on the arrangements to completion, and to submit a definite proposal for vote of the Society thereon at its next meeting, on the basis of the recommendations now submitted.

It was moved by the Rev. Canon Baldwin, seconded by G. L. Marler, and unanimously resolved:—"That in accordance with the constitution of this Society, the proposal now read for Union with the Fraser Institute, in so far as the collections and library of the Society are concerned, be submitted to the meeting to be held in January, for final vote thereon, and that notice be given by circular to each member of the Society of the business to be submitted."

"That in the meantime, the Committee be instructed to complete the necessary arrangements, as far as possible, with the Fraser Institute, and also with the Royal Institution."

Rev. R. W. Norman, M.A., was elected a resident member.

In consequence of the unavoidable absence of the author, a paper by Mr. H. G. Vennor, of the Geological Survey, on the Galena and Plumbago Deposits of Eastern Ontario, was read by the Recording Secretary.

The President subsequently remarked that it was unfortunate that Mr. Vennor was not able to be present, as on some points suggested by the paper just read, further information was desirable. A short discussion ensued, at the conclusion of which the meeting was adjourned.

Special Meeting, called instead of the ordinary Monthly Meeting for January 31st, 1876.

In accordance with a resolution to that effect, passed on the 29th of November last, the present meeting was called by a circular mailed to each member, of which the following is a copy:

MONTREAL, January 22, 1876.

SIR,—You are requested to attend a Special Meeting of the Natural History Society, to be held at its Rooms, on Monday evening, January 31st, at 8 o'clock precisely, instead of the ordinary monthly meeting.

Your obedient servant,

J. F. WHITEAVES, *Secretary.*

BUSINESS: Final consideration of the proposed connexion of the Society with the Fraser Institute.

A copy of the following Memoranda was also sent at the same time to each of the members:

MEMORANDUM *of the Terms upon which it is proposed to transfer the Museum and Library of the Natural History Society to the custody of the Fraser Institute.*

1st. The Natural History Society agrees to transfer its Museum and Library, also any movable cases, furniture or fittings, that it possesses, permanently and without reserve, to the custody of the Fraser Institute.

2nd. The Natural History Society agrees to pay to the Governors of the Fraser Institute, the net proceeds arising from the sale of their land and building after payment of the undermentioned liabilities:

a $1000.00 Mortgage and any interest which may have accrued thereon.

b $4000.00, the amount of the Somerville bequest.

c $2000.00, the amount due to the Royal Institution for the Advancement of Learning, on account of the land now held by the Natural History Society.

MEMORANDUM *of the Terms upon which the Governors of the Fraser Institute agree to accept the custody of the Museum and Library of the Natural History Society.*

1st. The Governors of the Fraser Institute agree to provide a suitable building for a Museum of Natural History, of not less capacity than that which now contains the collections of the Society, together with such cases or fittings as are required and cannot be furnished by the Natural History Society.

2d. The Governors of the Fraser Institute agree to provide for the Society, free of expense, suitable lecture and committee rooms; the former for the delivery of free popular lectures, and for the annual and monthly meetings of the Society; the latter for its Secretary's office, and for its Council and Committee meetings. Also a room for the Curator of the Museum, and a work-room for a Taxidermist. The said rooms to be of not less capacity than those used for these purposes in the present building of the Society.

3d. The Governors of the Fraser Institute agree to provide for the safe-keeping of the collections, and for their proper and scientific arrangement by competent Curators and otherwise. The salaries of such officers to be paid by the Institute.

4th. The Original Museum and Library of the Natural History Society, with such additions as may from time to time be made by the Society, shall be known and distinctly labelled as the Collection and Library of the Natural History Society of Montreal. The books many be incorporated with the general library of the Institute, but are to be stamped with the name of the Society.

5th. The Museum shall at all times be open to the inspection of the Council of the Natural History Society, or of such other officer or officers as the Society may appoint.

6th. The Council of the Society shall have power to make recommendations to the Governors of the Institute as to the safe keeping and improvement of the Museum, and shall be consulted in any contemplated changes of its arrangement or management.

7th. The Society shall have power to add to its Museum and Library, from time to time, such specimens and books as it may acquire, and the books of the Natural History Society shall have the same care as those of the Fraser Institute.

8th. The Museum and Library shall be opened to Members of the Society and their friends, on terms not less liberal than those provided for by the present rules of the Natural History Society.

9th. All current expenses connected with the maintenance of the accommodation specified in clauses 1 and 2, such as furniture, repairs, city assessments, fuel, lighting, cleaning and insurance, are to be paid by the Fraser Institute.

NOTE.—The dimensions of the present Museum of the Society are 87 x 42½ feet, with a gallery entirely round the room, two sides 5 ft. 8 in. wide; one side 17 ft. 4 in., and one do. 16 ft. 8 in. wide, and there is also available space in two halls, and on the sides of the staircase. The Lecture room is 42½ feet x 43 feet, and folding doors permit the Library, 28 x 16 feet, to be thrown in.

The President and Council of the Natural History Society, would suggest in the event of the proposed transfer being mutually agreed upon, that the Governors of the Institute should secure the services of J. F. Whiteaves, Esq., the present Scientific Curator of the Natural History Society, as it would, in their opinion, be impossible to find any one so well fitted by local experience and otherwise to undertake the duty of the re-arrangement and classification of the collections in the new Museum; and also its subsequent superintendence.

There were twenty-two members present.

On motion of Principal Dawson, Rev. Dr. De Sola was requested to take the chair.

The presiding officer, after briefly stating the nature of the business which the meeting was specially called to consider, regretted the absence of the President, who had taken an active part in the negotiations with the Governors of the Fraser Institute, and called upon the Recording Secretary to read the minutes of the last monthly, and of the last two Council meetings, also a copy of the "Memoranda" printed above.

On behalf of the Committee appointed to confer with the Governors of the Fraser Institute, Principal Dawson gave a verbal report of the action taken so far, and stated the terms of the agreement arrived at between the Governors of the Royal Institution and the Natural History Society, in the event of the sale of the buildings and ground at present occupied by the latter corporation.

The following resolutions (which were subsequently amended by consent of the mover and seconder, so as to include some additions, suggested later on in the evening), were moved by G. L. Marler, seconded by Prof. Darey:

"That the report now presented be adopted as amended, and the terms therein stated for union with the Fraser Institute, be, and hereby are, accepted by this Society, and that the Council be, and hereby is, empowered to prepare and execute the necessary agreements and deeds so soon as the building of the Fraser Institute shall be erected, and the Trustees thereof be in a position to carry out the stipulations entered into by them. The Council shall have the drafts of the said agreements and deeds prepared with legal advice, and shall submit them to the Society before signature."

"Farther, that the said deeds and agreements shall contain provision for the disposal of the collections and library, in event of either the Fraser Institute or Natural History Society ceasing to exist as at present constituted, or failing to fulfil its obligations."

The "Memoranda" were then discussed, paragraph by paragraph, and upon a motion to that effect being made, it was resolved unanimously:

"That the words—for use as a free Museum and Library—be added to the first paragraph of the first Memorandum."

It was moved by Dr. P. P. Carpenter, seconded by C. Robb:

"That the words—'permanently and without reserve'—be struck out of the same paragraph."

The motion was put to the meeting, and was declared by the Chairman to be lost.

Dr. P. P. Carpenter moved, seconded by G. L. Marler:

"That the following qualification be added to paragraph 3 of the second 'Memorandum,' after the word Institute—'But no appointment of Chief Curator shall be made without ratification by the Society.'"

This resolution was unanimously adopted.

The main motion was then submitted to the meeting, and was carried *nemine contradiscente.*

4th Monthly Meeting, held February 28th, 1876.

Messrs. Armand Thielens (Director of Posts, Tirlemont, Belgium), Professor Edouard Morren (University of Liege, Belgium), André Devos (Conservator of Botany, University of Liege, Belgium), and Robert Middleton, of Victoria, Vancouver Island, were elected corresponding members.

Mr. J. W. Spencer then read a paper "on the Nipigon or Copper-bearing Rocks of Lake Superior, with notes on Copper Mining in that region," which is printed on pages 55-81 of the present volume.

A discussion took place after the reading of the paper, in which Messrs. A. R. C. Selwyn, Principal Dawson, Prof. R. Bell, and C. Robb took part. The points upon which most of the speakers seemed to agree were: 1st, that lithological and stratigraphical differences exist between the beds on the north and south shores of the Lake, and that a satisfactory correlation of the deposits at these two localities has not yet been established; and, secondly, that the exact geological horizon of the copper-bearing series is still uncertain.

Principal Dawson called the attention of the members present to an interesting collection of ferns and other fossil plants which had been recently obtained by Mr. Albert J. Hill from Cossett's Pit, near Sydney, Cape Breton, some of which were exhibited. He said they were of interest as showing the occurrence of forms hitherto known only in the middle and upper coal formations in beds assigned, on stratigraphical evidence, to the upper part of the Millstone-Grit. They were also of interest from the presence of at least four species of ferns showing fructification, which would shortly be described. They were further of interest as occuring in the same beds with the remains of a fossil larva of a dragon-fly, which will be described by Mr. Scudder in the next number of the *Canadian Naturalist*, and which is the first insect of that family found in the Carboniferous Rocks.

5th Monthly Meeting, held March 27th, 1876.

A paper by Mr. G. M. Dawson, entitled "The Grasshopper visitation of 1874 in Manitoba and the North West Territories," was read by Principal Dawson.

After some remarks on this subject by A. R. C. Selwyn, Prof. R. Bell, E. L. Marler, C. Robb, and Principal Dawson, the proceedings terminated by a vote of thanks to the author of the paper of the evening.

6th Monthly Meeting, held April 30th, 1876.

Mr E. J. Major was elected a member of the Society.

A paper by Lieut. Col. Bulger, entitled "A visit to Port Blair and Mount Harriet, Andaman Islands," was read by the Rec. Secretary and an interesting collection of shells from that

locality (presented by Lieut. Col. Bulger) was exhibited. The paper may be found at pages 95–103 of the last number of this Journal.

A letter from Lieut. Col. Bulger was also read in which it was endeavoured to interest the members in the taking of phenological observations, and the scope of a pamphlet forwarded by Mr. Bulger, giving instructions for the taking of the same, was explained by the Rec. Secretary.

A committee was appointed, to consist of Dr. John Bell, J. B. Goode, F. B. Caulfield and the Rec. Secretary, with power to add to their number, to endeavour to draw up a series of instructions for the use of phenological observers in the Dominion.

SOMMERVILLE LECTURES.

The following is a list of the titles of the lectures of this course, with the dates at which they were delivered, and the names of the lecturers.

1. Jan. 20th, 1876. Insectivorous Plants. By Principal Dawson LL.D., F.R.S.
2. Jan. 27th, " A bit of life on the Ocean. By W. G. Beers, L.D.S.
3. Feb. 3rd, " Some facts in Psychology. By Dr. G. A. Baynes.
4. Feb. 10th, " Selections from the study of Vegetable Life. By Prof. J. B. McConnell, M.D.
5. Feb. 17th, " Animal Parasites and their relation to Public Health. By Prof. W. Osler, M.D.
6. Feb. 24th, " The climatology and resources of our North West. By Prof. J. Macoun, of Albert College, Belleville.
7. March 2nd, " Spiritualism, as viewed in the light of the Baconian Philosophy. By Rev. J. T. Stevenson, L.L.B.

ANNUAL MEETING.

The Annual Meeting was held on the 18th of May, 1876, Mr. Charles Robb presiding.

After the minutes of the last Annual Meeting had been read, the Rec. Secretary read a letter from the President, A. R. C. Selwyn, F.R.S. (who was absent in Philadelphia), expressing his regret at not being able to be present, and distinctly declining

re-nomination on the ground that he found it impossible to attend properly to the duties of the office.

The following report of the Chairman of Council was read by Mr. G. L. Marler.

REPORT OF THE CHAIRMAN OF COUNCIL.

Your Council in presenting its annual Report deeply regret to announce the loss of four life members, who were distinguished alike for their long connection with the Society and for the deep interest they took in its proceedings. In mentioning the name of Sir William E. Logan, there is little need for me to do more than allude to his geological researches: the result of his life-long labours are known to you all, and have secured for him a high place in the annals of Canadian science.

Sir G. Duncan Gibb, whose recent loss we have also to deplore, although not lately a resident in Canada, was once a very active member of this Society, and was at one time the Scientific Curator of its museum. He was fond of the study of Natural History, and contributed the following papers to the Society's Journal:

1. A Pedestrian Tour from Brighton to Hastings.
   (*Canadian Naturalist*, 1st series, vol. 2, page 382.)
2. On the existence of a Cave in the Trenton Limestone at the Côte St. Michel, on the Island of Montreal.
   (*Canadian Naturalist*, 1st series, vol. 3, page 192.)
3. The Natural History of the *Sanguinaria Canadensis*, or Canada Blood Root.
   (*Canadian Naturalist*, 2nd series, vol. 2, page 432.)

The late John Swanston, of the Hudson's Bay Co., was also a warm friend and strong supporter of the Society, to whose museum he made many valuable contributions. George H. Frothingham, another life member, has been removed from among our midst; as has also Mr. Walter McOuat, with whose reports, as a member of the staff of the Geological Survey, many here will be familiar.

While death has thus severely visited the Society, the increase to its ranks has been very small, only two new members having been added during the session; though, on the other hand, in spite of the prevailing commercial depression, fewer resignations than usual have been received.

The arrangements for the transfer of the museum and library of the Society to the custody of the Fraser Institute, have, as you are aware, been completed as far as possible, and the terms of union agreed upon. Your Council are of opinion that by the proposed transfer the Society will be relieved of much pecuniary responsibility, and that in future it will be able to devote its funds more exclusively to such objects as the improvement of the library and museum, as well as to that of the "Canadian Naturalist."

The regular monthly meetings have been held during the past session, to the number of six, and were very fairly attended. The titles of the papers read will be found in their proper place in the Proceedings of the Society.

Your Council regret to report that the Government has seen fit to discontinue deep-sea dredging operations in the Gulf of St. Lawrence, but your Council hope that the discontinuance will be only temporary, and that the Government may be again induced to resume this most interesting and important work.

The lecture room has been rented during the year, and the sum of $347.00 has thus been added to the funds of the Society.

The Sommerville Course of free public Lectures have been delivered as usual, and that they have been fully appreciated is shewn by the large audiences by which they were attended. The subjects of the lectures, the date at which they were delivered, and the names of the lecturers, will be found in the Proceedings.

The customary grant of $750 has been duly received from the Provincial Parliament, but an application for an increase of the amount was unsuccessful.

At the suggestion of Lieut.-Col. Bulger a Committee has recently been appointed to issue directions for the use of phenological observers, and your Council would urge upon its successors the desirability of taking prompt action in this matter.

Arrangements have just been completed for the whitewashing and re-tinting of a large portion of your building.

The number of persons visiting the museum has been about equal to the average of former years.

Owing to the backward state of the season, it was thought desirable to postpone the holding of a field meeting on the Queen's birth-day.

The report of the Scientific Curator and Rec.-Secretary was then read as follows:

REPORT OF THE SCIENTIFIC CURATOR.

A large part of the time during the past session has been devoted to the completion, as far as possible, of the re-classification of the Society's collection of Canadian insects. Since the cabinet was first arranged, in 1865, numbers of new specimens have been added, and these were, from time to time, pinned into any convenient place, until the whole should be re-arranged. Catalogues of the coleoptera of the island of Montreal have been published by Mr. D'Urban and the late Mr. A. S. Ritchie, in the *Canadian Naturalist*. These collectively make up a list of about 300 species. Mr. Ritchie's collection, which was specially valuable as having been named by Drs. Horn and Leconte, is now in the possession of the London branch of the Entomological Society of Canada. The first step taken towards an entire re-arrangement of the Society's rather extensive collection of Canadian beetles was to compile a MSS. catalogue, based on the lists referred to above, of the species so far known to inhabit the island of Montreal. During the past few years Mr. Caulfield, Mr. Passmore, and myself, have given a good deal of spare time (mostly Saturday afternoons in summer), to the collection of local coleoptera. We have been able to add about 80 identified species to the lists already published, while a number of specimens remain yet to be named. After completing this MSS. list, 4 drawers in the cabinet were selected and spaces, with a printed label to each, were allotted for every species known to inhabit the Island. Efforts have been made to fill these spaces with new and high pinned specimens, and the result has been that 193 species were obtained. The important collection recently presented by Mr. Billings, has been removed from the collecting boxes in which it was originally contained, and the insects pinned into the cabinet. The remainder of the collection consists of such specimens as are not in either of the two previously mentioned series. This part of the cabinet, which was previously in a state of chaotic confusion, is now in very fair order, all duplicates having been rejected, also specimens without either locality or name. The Coleoptera now fill 7 drawers, in three separate series, as follows:

1. Beetles from the Island of Montreal exclusively, 193 species.
2. Mr. Billings' collection - - - - 444 "
3. Specimens mostly from the Province of Ontario, 198 "

In all - 835 "

While engaged in endeavouring to collect fresh specimens of local beetles for the cabinet, other orders have not been neglected, and fair series of hymenoptera, diptera, and orthoptera have been obtained. The proper setting of large numbers of insects, and their correct determination, has of course taken up considerable time.

During Mr. Selwyn's explorations in the vicinity of the Peace River, attention was given to collecting the insects of that region. A large series of coleoptera were brought from that part of the world, and were kindly presented to the Society by Mr. Selwyn. The whole of these have been sent to Dr. Leconte, of Philadelphia, who has kindly promised to report upon them. When they are returned they will form a very valuable and indeed unique feature in our cabinet. Dr. Leconte moreover promises to examine and determine all our local coleoptera which remain unnamed, particularly the Curculionidæ, of which little or nothing is known at present. The whole of the Canadian Lepidoptera have also been re-arranged, and the collection now fills 6 drawers. Many of our local species are still unrepresented, and entomologists are respectfully reminded of the many vacancies to be met with in this part of our cabinet. As a great difference of opinion unhappily exists as to what is the proper nomenclature in this group, the old names have been provisionally retained.

Dredging operations have been carried on during the past summer in the Gulf of Georgia by Mr. Richardson. The dredgings extended from outside Victoria Harbour to within a short distance of Race Islands lighthouse and thence to the Constance bank, the average depth being from 25 to 50 fathoms. A few successful casts were also made in Baynes Sound, also between Texada and Harwood Islands. The specimens obtained in this way are of unusual interest; there is one small sponge; six Echinoderms; thirteen species of Polyzoa, many of which are new to science; fifty-four species of Mollusca, and four Crustacea. Three of the shells are novelties, two of which have recently been described by Mr. Dall from Alaska, which was the

only previously known locality for them, while ten are new to the fauna of the Gulf. Mr. Richardson also collected thirty-one species of marine shells in the neighbourhood of Victoria, and of these three are new to the district. The whole of the specimens collected by Mr. Richardson have been presented to the Society by its worthy President, to whom the Society is already so largely indebted. Thanks to his liberality, the Society now possesses quite a rich collection of the products of the Pacific coasts of the Dominion. It has been quite a labour of love to study these interesting and often unique specimens: the whole of the Mollusca, eighty-five species in all, have been carefully determined, as have also most of the Echinodermata. We have also received during the past session a small but beautifully prepared series of the crustacea, marine algæ, &c., of Vancouver Island, prepared by Mr. R. Middleton of Victoria. The crustacea have been sent to Mr. S. J. Smith of Yale College for identification, and have been since returned. There are six species, most of which are rare in collections, while one is entirely new. The Hydroids were sent to Prof. Verrill, who in returning them, reports that there are seven species, all referable to well-known Californian types. Mr. W. H. Dall, who has spent many years in exploring the marine zoology, &c., of Alaska and the Arctic fauna of the Pacific, paid Montreal a visit last August, and spent several days in examining and making notes on the shells from the Gulf of St. Lawrence in the Society's collection. Unfortunately, Mr. Richardson's shells had not been received when Mr. Dall was here, but a list of the whole of them was forwarded to him at Washington, and many of the most critical of the shells themselves. Dr. J. Gwyn Jeffreys, who superintended one of the dredging cruises of the Porcupine, accompanied the British Arctic expedition as far as Greenland, in H. M. S. Valorous. An accident occurred to the vessel, which somewhat interfered with dredging operations; still Dr. Jeffreys' cruise was not altogether unsuccessful, and he is now engaged in a study of the specimens obtained. He has expressed a wish to see several of the shells obtained in the Gulf of St. Lawrence on recent dredging expeditions, and they have accordingly been sent to him; these have also been since returned. The Society has now had the advantage of having all its St. Lawrence shells critically compared with Arctic Atlantic forms by the ablest living authority on the mollusca of the north of Europe, and as complete a set of duplicates as could be spared were forwarded to

Mr. Dall for comparison with nearly related forms from the Arctic waters of the North Pacific, in his cabinet.

Some progress has been made in the determination of such species of marine animals (obtained during three dredging expeditions to the Gulf) as had not been previously studied. My own time has been given to the sponges and polyzoa, also to a revision of the mollusca. About fourteen species have been added to the known fauna of that region. Several critical crustacea and echinoderms, dredged by Principal Dawson at Metis last summer, have been sent to Profs. Smith and Verrill, who have kindly reported thereon. The whole of the echinodermata from the Gulf in the collections of Principal Dawson and of the Society are now determined.

Lieut.-Col. Bulger, whose donations to the Society have been so numerous and valuable, has added to his favours by presenting to the Society a fine collection of the shells of the Andaman Islands in the Bay of Bengal. It contains 137 species, in excellent order, most of which have been mounted on tablets, and 87 have been named.

In last year's report it was stated that the whole of my own private collection of fossils and shells had been imported from England. They fill four large packing cases, and had not been opened for fourteen years. It was found that many of the most delicate shells had been attacked by mildew, and some had been so much injured as to be worthless. An attempt has been made to remedy this state of things, but my time has been so much occupied with other work that only two of the cases have been opened.

At a late meeting of the Library Committee, I was requested to examine into and report upon the present condition of the library. All the American exchanges that are unbound have accordingly been tied up in volumes, and the numbers of the missing parts, or the word complete, as the case may be, written on each set. The whole of the Society's collection of pamphlets has been gone through with the view of selecting sets for binding.

The ordinary secretarial duties, such as the calling of meetings, the posting of the minutes, and other routine work, has been much the same as in past years, but the purely scientific correspondence entailed by the constant addition of new specimens, is very largely on the increase.

The report of the Treasurer was next read by Mr. E. E. Shelton. This will be found on the next page.

Dr. THE NATURAL HISTORY SOCIETY *in account with* E. E. SHELTON, *Treasurer.* *Cr.*

1875–'76.		1875.	
To cash paid Mr. Whiteaves	$400.00	By Balance in Treasurer's hands	$509.57
" " Mr. Passmore	200.00	1876.	
" " Foote's com. on Collections	16.15	By Government grant	750.00
" " Coal and Wood	107.06	" Members' Yearly Subscriptions	355.00
" " Gas Bill	56.70	" Museum Entrance Fees	51.50
" " Water	42.05	" Rent of Rooms	347.00
" " City Taxes	82.50	" Cash for 7 vols. of the Naturalist	10.00
" " Insurance	35.00		
" " Repairs and petty expenses	128.30		
" " Dawson Bros.—Naturalist	175.30		
" " Printing and advertising	79.34		
" " Interest to Royal Institution	80.00		
" " Prof. Macoun's Lecture	16.75		
" Balance in Treasurer's hands	603.92		
	$2023.07		$2023.07

E. & O. E.
Montreal, 17th May, 1876.

Audited and found correct after comparing with vouchers.

G. L. MARLER,
J. H. JOSEPH, } *Auditors.*

On motion of Dr. J. Baker Edwards, seconded by Prof. Darey it was resolved:

"That the reports now read be adopted and printed in the *Naturalist*, and that it be a suggestion to the new Council to take such measures as may seem feasible to bring under the notice of the public the importance of the operations of this Society and its claims to a more extended and liberal support from the community."

The election of officers was then proceeded with, and it was moved by G. L. Marler, seconded by E. E. Shelton, and resolved:

"That the by-law providing for the election of every officer by ballot, be suspended, and that Principal Dawson be elected President by acclamation."

Mr. E. E. Shelton was also re-elected as Treasurer, Prof. Darey as Corresponding Secretary, and Mr. J. F. Whiteaves as Scientific Curator and Recording Secretary, in the same way, the form of balloting being dispensed with in each case, by a special resolution to that effect.

Messrs. J. B. Goode and Prof. R. Bell having been appointed scrutineers, the following officers were elected by ballot in the usual way:

Vice-Presidents,—A. R. C. Selwyn, F.R.S., F.G.S.; Rev. A. De Sola, LL.D.; J. Baker Edwards, Ph.D., D.C.L.; C. Robb; His Lordship the Metropolitan; G. L. Marler; and E. Billings.

Council,—Prof. R. Bell, Dr. B. J. Harrington, R. W. McLachlan, Rev. Canon Baldwin, J. H. Joseph, J. B. Goode, Dr. W. Osler, N. Mercer, and M. H. Brisette.

It was moved by Dr. J. Baker Edwards, seconded by Prof. Darey, and resolved unanimously:

"That the thanks of the Society be voted to Dr. Harrington for his valuable services in editing the *Naturalist*."

It was also moved by G. L. Marler, seconded by E. E. Shelton, and resolved:

"That the Library and Membership Committee of last year be re-elected."

On motion of Prof. Bell, seconded by J. B. Goode, a vote of thanks was passed to the officers of the past session.

DONATIONS TO MUSEUM AND LIBRARY—SESSION 1875–76.

From	TO THE MUSEUM.
A. H. Foord, F.G.S.	Two species of Sponges, 7 of Polyzoa, an isopod crustacean (*Œga psora*, Linn) and some marine shells, from Cape Cove, and Percé, Gaspé.
Lieut.-Col. Bulger, F.R.G.S., L.S., Z.S.,	137 species of shells, mostly marine, from the neighbourhood of Port Blair, Andaman Islands.
	Skin of Sonnerat's Jungle fowl. Male. *Gallus Sonneratii.*
Dr. W. E. Scott.	Specimen of the Sulphur Crested Coakatoo.
Mr. James Leslie.	Water snake, *Nerodia sipedon.*
A. Lewis, Esq.	Fine inlaid Indian stone pipe-bowl from the North-West.
W. McLennan, Esq.	Indian stone pipe and 12 species of insects from Savannah.
J. B. Goode, Esq.	Large dried frond of *Polystichum lonchitis*, from Cape Bon Ami, Gaspé.
Dr. Godfrey.	Long-tailed Duck, *Harelda glacialis.*
James Gardner, Esq.	*Plexaura crassa*, and a large Asterias, both from Bermuda.
The Geological Survey, per A. R. C. Selwyn, F.R.S., &c.	85 species of marine shells, 6 do. of echinodermata, 5 do. of crustacea, and 13 do. of polyzoa, also axis of a large Gorgonia, all from the Gulf of Georgia.
Robert Middleton, Esq. Victoria, Vancouver Island.	A fine series of mounted sea-weeds, also 7 species of hydroids, 4 of polyzoa, floats of Portuguese man-of-war, and 6 species of crustacea, all from the neighbourhood of Victoria, V. I.
N. P. Leach, Esq.	The "Black Longe" of Lake Memphremagog, *Salmo confinis* Dekay, from Magog, P. Q.

From	TO THE LIBRARY.
The Author.	Report on the Geology and Resources of the Region in the vicinity of the Forty-ninth Parallel, from the Lake of the Woods to the Rocky Mountains. By G. M. Dawson, F.G.S., &c.
The Author.	Revision of the North American Porifera. With remarks upon foreign species. Part 1. By Alpheus Hyatt.
Trustees of the British Museum.	Catalogue of Cyclostomatous Polyzoa in the British Museum. By G. Busk.
	Catalogue of Birds. Volume 2.
The Dominion Government.	Statutes of Canada, 38th Victoria, 1875. Vol. 2. (In French.)
The Author.	Annuaire de Ville Marie, origine, utilité et progrès des Institutions Catholiques de Montreal. Supplement a l'edition de 1864. Par L. A. H. Latour, M.A., &c.
The Cobden Club.	Free Trade and the European Treaties of Commerce. Being a report of Proceedings at the dinner of the Cobden Club, July 17th, 1875.
The Belfast Naturalists Field Club.	Guide to Belfast and the adjacent Counties.
Executors of the late Henry Christy, Esq.	Reliquiæ Aquitanicæ. Parts 11 to the end, inclusive.

THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

ON THE PRE-GLACIAL GEOGRAPHY OF THE REGION OF THE GREAT LAKES.

By E. W. Claypole, B.A., B. Sc. (London), Antioch College, Ohio.

The alliance of Geology with Physical Geography is not of long standing. Each science had separately done good work before by combining their forces they attempted yet greater undertakings. When Geology discovered and published the fact that the present outlines of the earth's surface had not always existed Physical Geography demanded the reproduction of the outlines passed away. The sister sciences thereupon joined hands, and set themselves to the task of reconstructing what we may call Extinct Geography. Long and arduous as it is, their efforts have already been crowned with no small measure of success—a success the greater, as might be expected, in proportion as the date is more recent. Quaternary maps are more full and correct than Tertiary, and Tertiary than Secondary; while the palæozoic coast-survey has hardly yet begun.

The following attempt to reconstruct the early Quaternary Geography of the great American Lake District is offered as a small contribution to this department of science. The region is one of the most interesting upon the continent, both to the geologist and the physical geographer. Speculations have been made on the origin of these great inland sheets of water, but the

writer has not met with any connected or detailed investigation into the physical cause of the basins in which they lie, and which determine their existence. Until lately no proposition at all tenable had been promulgated; but since Professor A. Ramsay's strong advocacy of a glacial origin for the basins of certain European lakes, there seems to have been a tacit extension of this theory, so that according to some it explains the formation of almost all lakes in the North Temperate Zone, and were it not for the existence of several great inland seas in Equatorial Africa, it would, we think, be accepted by not a few as the sole and sufficient cause of all lake basins on the surface of the globe.

The merits of this theory we do not propose now to examine. Our purpose is merely to test its application to the case of the great North American lakes. The publications of the Geological Survey of Ohio have shown that opinion is yet divided upon this point. Dr. Newberry, its director, is apparently himself in doubt, as we infer from expressions in different parts of the work. For instance, we read in the volume for 1869, p. 28:

"Lake Erie in the glacial era was not a lake but an excavated valley into which the streams of Northern Ohio flowed."

But in the volume for 1873, Dr. Newberry says:

"It is doubtless known to some who may be readers of this volume, but probably is realized by few, that the basin of Lake Erie in all its length and breadth—as well as the smaller and yet deeper one of Lake Ontario, and the broader and far deeper ones of Lakes Michigan and Huron—has been excavated by mechanical force from the solid rock. . . . They are plainly basins of excavation dug out of sheets of rock which were continuous over all the area they occupy. . . . Any one who will stand on the cliffs which overlook the lake in North Eastern Ohio, 750 feet above the water, and will look over the sea-like expanse toward the Canadian shore, will get some realizing sense of the vastness of the mechanical effect which has been produced here. . . . The agents were unquestionably the same that have produced all the great monuments of erosion seen elsewhere—*water* and *ice*; and of the two that which was by far the most potent and that which alone could excavate broad boat-like basins such as these was Ice." p. 49.

Again we read in the volume for 1874, p. 77:

"Previously to the glacial period the elevation of this portion of the continent was considerably greater than now, and it was

drained by a river system which flowed at a much lower level than at present. At that time our chain of Lakes—Huron Erie, and Ontario—apparently formed portions of the valley of a river which subsequently became the St. Lawrence, but which then flowed between the Adirondacks and the Appalachians in the line of the deeply buried channel of the Mohawk, passing through the trough of the Hudson. . . . Lake Michigan was apparently then a part of a river course which drained Lake Superior and emptied itself into the Mississippi."

It is somewhat difficult to reconcile this with the next paragraph, which is as follows:

"With the approach of the cold period, local glaciers formed on the Laurentian mountains, and as they increased in size gradually crept down, and began to excavate the plateau which bordered them on the west and south. *The excavation of our lake basins was begun and perhaps in large part effected in this epoch.* The extent of the erosion produced *in the epoch under consideration* will be best appreciated by one who will stand on the cut edges of the great series of rocks exposed on the southern slopes of Lake Erie and Lake Ontario, and in imagination fill the vast vacuity which separates him from the base of the Laurentian hills."

On a previous page (72) we read the following:

"All our great lakes are probably very ancient," and "their formation may have begun during the coal measure epoch."

And on p. 74:

"There can be no doubt that the basin of each of the great lakes has been produced by a local glacier. . . Our lake basins must have been formed before or after the continental glacier, or both before and after."

And once more we find in the volume for 1873, p. 172, when speaking of the buried river channels, of which mention will be made presently, Dr. Newberry says:

"They were formed at a time when Lake Erie did not exist as a lake but was represented by a river flowing through some portion of the basin it occupies, and receiving the Cuyahoga, Rocky River, the Chagrin, Grand River, &c., as tributaries, at a level 200 feet below the present mouths of these streams. This was anterior to the first epoch of the drift period."

The view expressed in the last extract appears to be the only one now tenable, and the object of this paper is to support and to extend it to other parts of the region of the great lakes.

No fact has been more clearly brought to light during the Geological Surveys of New York and Ohio than that the present rivers are not flowing, in all cases, where they flowed during the Tertiary age. When the ice advanced southward it obliterated the rivers then existing, and on retiring left their channels filled with stones and clay. These beds of drift, as they are called, remained after the ice had disappeared, and when the rivers began again to flow, they failed, in many cases, to find their ancient beds. These ancient channels remained filled with clay stones and sand, and have only been discovered by borings and cuttings made generally for economical purposes. A good instance of this will be found in the volume of the Geological Survey of Ohio for 1873. Prof. Orton writes in his account of Clarke County—p. 460 :

"An old valley of Mad River is disclosed in the heavy cut of the Atlantic and Great Western Railway, a few miles west of Springfield. The tongue of land that occupies a bend in the river has an elevation of 100 to 125 feet above the level of the stream, and gives no hint in its contour of any break in the rocky floor underlying it. The Sandusky railroad, which was first in construction, cuts across the tongue. A considerable portion of this cut is wrought in solid rock, the maximum depth of the stone cutting being 18 feet. With these facts before them, the Atlantic and Great Western Company, whose line crosses the river half a mile higher and on a grade of ten feet below the first road, expected also to find rock, and made arrangements for tunnelling the hill. The road that they selected however, chanced to be a buried channel of the river, which allowed an open cut of 65 feet through clay and sand. Soundings that have since been made from the track to the level of the river, show drift material throughout the whole extent."

In the north of the State, near Cleveland, where the Cuyahoga River enters the lake, is another of these buried channels. Borings have revealed the fact that the Cuyahoga now flows over a bed of clay and sand, 220 feet in depth, filling an older channel in the same or nearly the same place, whose rocky bottom lies 210 feet below the level of the lake. Ten miles west of Cleveland the Rocky River also enters the lake by a deep channel with precipitous walls. But two miles to the west is found its ancient channel filled like that of the Cuyahoga with clay, the Erie clay—"which here as at Cleveland extends far below the lake level." 1873, p. 172.

Now a river cannot excavate its bed below the bottom of the valley or lake into which it flows, and as Lake Erie does not much exceed 200 feet in depth, it follows of necessity that the bottom of the channel of the Cuyahoga and the bottom of the lake are nearly on the same level. It is impossible therefore to doubt that at the time when this older Cuyahoga flowed along its now buried channel the Erie valley had been excavated *to its full depth*, and that whatever was the agent we cannot attribute the erosion to the ice of the glacial era, since both valley and river equally belong to pre-glacial times.

Another argument may also be founded on the facts above given concerning the Cuyahoga. It is frequently affirmed that enormous erosion occurred over the face of the country during the ice age, and that, even if we grant the existence of an excavation where Lake Erie now lies, yet that excavation must have been deepened and widened under the action of the continental ice sheet. But no one will maintain that the ice deepened the gorge of the Cuyahoga from Cleveland to Boston, fifteen miles back from the lake, and it is equally impossible to maintain that the Erie basin which lies at nearly the same level can have been much deepened during the glacial era. The higher parts of the country may have been somewhat worn down, and the basin of the lake slightly eroded, but there is absolutely no evidence proving any perceptible change in the outline and depth of the Erie valley since early Quaternary days.

Yet a third inference may be drawn from the relative conditions of the Cuyahoga and the Erie Valley at the time now under consideration. There is no reason to believe that the river at Cleveland was much larger than now while it is absolutely certain that it flowed at least 200 feet below its present level, or nearly on the bottom of the present lake. We may hence safely conclude that the lake had no existence, and that the bed of the Cuyahoga continued into the wide open vale of Erie without meeting any such inland sea as that into which it now falls, and emptied itself into some larger stream then flowing eastward through the valley.

The same was also in all probability true of the Rocky River, and of other streams now tributary to the lake. For example: "Borings at Toledo show that the old bed of the Maumee is at least 140 feet below its present surface level." Geological Survey of Ohio, 1874, p. 15. The instances given are however sufficient for our purpose, and we pass on.

The establishment of this conclusion is however only the first step. If it is proved that the Erie valley existed not as a lake but as a valley at the time in question, other changes must follow. We quote again from the Survey of Ohio :

"An old excavated and now filled channel connects the basins of Lake Huron and Lake Erie. At Detroit the rock surface is 130 feet below the city. In the oil regions of Enniskillen and Bothwell, on the opposite side of Detroit river, from 50 to 200 feet of clay overlie the rock where the land surface is but little above the level of Lake Huron. The greatest depth of this channel is unknown."

The existence of this old and buried chanel at Detroit is another link in the chain. It enables us to extend our inferences from the valley of Erie to the basin of Lake Huron. It is evident that if the former in pre-glacial times contained no lake, and was connected with the latter by this channel 200 feet in depth, now filled with drift, the latter must also have been an open valley, and not, as now, the bed of an inland sea. The water collected upon its slopes must have flowed down to the mid-channel and thence through the deep gorge at Detroit into the Erie valley, forming the river previously mentioned.*

Turning now to the other end of Lake Erie, let us consider the physical condition of the Ontarian valley at the time in question. The greatest depth of Lake Ontario is 450 feet, with a surface level of 235 feet above the sea. Between the two lakes lie, as is well known, the falls of Niagara, which with the rapids below and above them, cause a descent of 330 feet. We have shown above that the valley of Erie cannot have been in early Quaternary times the bed of a lake, and it is therefore necessary to find some means of accounting for the escape of the

* It may be well in this connection to mention that the often expressed conception of these lakes as profound depressions is quite incorrect. They are excavations insignificant in depth when we consider their area. Lake Erie, with an average breadth of about 40 miles and a depth of 200 feet, lies on a bed whose sides slope only 10 feet in a mile. To the eye such a slope would appear an absolute level, and when we consider that a railway incline sometimes rises as much as 80 feet in a mile, the flatness of this valley to the eye will be more apparent. A similar calculation applied to Lake Huron shows that its bed slopes on an average not more than 16 feet in the mile, and like results may be obtained for all the others in the chain

waters. In the present state of our knowledge of the geology of the region it is impossible to point out the exact position of this channel, but the following extract will indicate its probable situation. After citing and discussing numerous instances of buried river-channels of pre-glacial age in different States, and relying on his experience and his knowledge of the geology of the country, Dr. Newberry says:

"I ventured to predict to General Warren that an old filled up channel would be found passing round the Mississippi rapids, and his examinations have confirmed the prophecy. I will venture still farther, and predict the discovery of buried channels of communication between Lake Superior and Lake Michigan, probably somewhere near and east of the Grand Sable, at least between the pictured rocks and St. Mary's river, *between Lake Erie and Lake Ontario through Canada*, between Lake Ontario and the Hudson by the valley of the Mohawk, and between Lake Michigan and the Mississippi somewhere along the line I have indicated before." Geology of Ohio, 1874, p. 19.

Of these the first, the channel between Lake Superior and Lake Michigan had already been announced in 1871 by Mr. N H. Winchell, then a member of the Michigan Geological Survey, in the American Journal of Science and Arts for July of that year. This paper is noticed by Dr. Newberry in the volume just quoted, page 13.

The existence of a buried channel therefore between Lakes Erie and Ontario, though not actually proved by boring as in the former case, yet rests on evidence not to be estimated lightly. The opinion of one so well acquainted with the country as Dr. Newberry, deserves great confidence, and as in other cases, so here, it is likely that further investigation will reveal the buried channel somewhere near the line of the Welland Canal.*

The condition of the Ontarian valley at the time in question

* It would be conducive to the interest of science, and might at the same time repay the expenditure of the public money if the Government of the Dominion would set on foot a systematic examination of the region before completing the section of the new Welland Canal that passes through it. If such a buried channel could be found through the great Upper Silurian escarpment which forms so striking a feature in the landscape between St. Catharines and Niagara and the excavation carried through it, the cost would certainly be less than that of a rock cutting.

now claims consideration. In the passage above quoted from the Geology of Ohio, mention is made of the existence of a buried channel between Lake Ontario and the Hudson River through the valley of the Mohawk. Many years ago, in the course of the Geological Survey of New York, the facts were discovered on which this opinion is based. They prove the existence of a deep drift-filled and therefore pre-glacial channel near Syracuse, in the course of which channel lies Lake Onondaga.

"Onondaga Lake is the remains of an ancient and deep excavation in the Onondaga salt group, of which Onondaga valley forms the southern part, all of which has been filled up with sand and gravel except the part occupied by the lake." Geology of New York, Third District, p. 241.

Professor Newberry says: "The long level of the Erie canal between Utica and Rome lies in the old partially filled valley of the Mohawk." Geology of Ohio, 1874, p. 16.

In this channel are bored the Salina salt wells, the deepest of which extends 414 feet below the level of the lake, and it is not certain that the rock was reached in this.*

Dr. Newberry says: "The rocky bottom of the valley of the Mohawk is far below the surface—how far is not known, *as it has never been reached.*"

These figures warrant the conclusion that there exists a buried channel leading south-east from some point in the Ontarian valley near Oswego to Lake Onondaga and thence eastward towards Rome and Utica in the valley of the Mohawk. Beyond this point it has not been investigated, but there can be little doubt of its communicating by the valley of the Mohawk with that of the Hudson somewhere near Albany. It is also reasonable to

* Geology of Ohio, Vol. II, p. 16. Here by an error the surface of the lake is put at 274 feet above the Atlantic. But as the survey of New York shews a fall of 66 feet in the upper Niagara rapids, 160 feet at the Falls, and 104 feet in the lower rapids, or 330 feet in all, it is evident that the surface of Lake Ontario must be 235 feet only above the ocean. The Survey of Canada also (1863, p. 10) gives the fall from the Lake to the Atlantic 232 feet, a discrepancy of only 3 feet. By another error we are here told that at 414 feet below the lake-level, we are only 50 feet below the sea-level, whereas if 234 be subtracted from 414, the difference shews that we must be 180 feet below the surface of the Atlantic. It is difficult to discover which of the given data is wrong—the depth below the lake or that below the ocean.

infer that its bottom lies nearly or quite as low as that of the lake, so that in the later Tertiary age before it was filled with clay and sand, the waters of the Ontarian valley must have found their way by Oswego, Syracuse, Rome, Utica and Albany to the sea. The present lake basin, therefore, like those of Lakes Erie and Huron, must have formed an open valley drained by the river whose upper course was pointed out above, and which, considering its lower course, we may well christen the "Pre-Glacial Mohawk."

An objection will here be raised which must be met. The bed of Lake Ontario lies 215 feet below the present level of the Atlantic, while the bed of Lake Erie is 330 feet* above it, consequently, while there is no obstacle to the flow of this ancient Mohawk from the Erie to the Ontarian valley, it will be impossible to explain its course from the latter to the sea. A like difficul'y is found in establishing the flow of the river from the Huron basin into that of Lake Erie, the bed of the former lying 230 feet below the Atlantic level, while that of the latter is 330 feet above it, giving an *ascent* of more than 500 feet. If the relative levels of sea and land were then as they are now, such a course for this pre-glacial river was impossible. But there is much reason to believe that *before* the coming on of the great ice age the present relative levels of land and sea did not exist. It is the opinion of many geologists, among whom we may mention Professor Dana, that the glacial era was a time of continental elevation in high northern latitudes, and that this elevation became less and less towards the equator. But whatever may have been the case at and before its commencement, it is more probable that during the ice age the land to the north underwent depression in relation to the sea, whether the result of a rise in the ocean waters or not may be left for the present undetermined. Be this however as it may, most geologists are agreed that *before* the ice age, during the later Tertiary and early Quaternary eras, the northern part of the continent was more elevated than now.

"The Atlantic coast of North America to the north of Cape Cod was higher than now during the Cretaceous and *Tertiary* eras, as is shown by the absence of sea-shore deposits of these eras." Dana's Manual, 1874, p. 540.

* In these figures no account is taken of the recent deposits in the beds of the lakes.

It will be necessary therefore to consider the bearings of this fact on the course of the pre-glacial Mohawk. It is difficult, perhaps impossible at present, to arrive at exact conclusions in regard to its amount or its rate of increase northwards, but a consideration of the phenomena presented by European and American geology inclines us to assume that it was not excessive, and that a rate of about three feet in a mile would not vary much from the truth. With this estimate then we must now calculate the effect of such an elevation on the various parts of the bed of the river, and in so doing it will be sufficient for our purpose to start from the mouth of the present Hudson River in the harbour of New York in north latitude $40\frac{1}{2}°$. The change would place the western end of the Erie valley 645 feet above the present Atlantic level, or 315 feet higher than now. But the same change would elevate the Huron valley in lat. 45° to a position 720 feet above the same level, and give a fall of rather less than 100 feet from the latter to the former, making the flow of the Mohawk not only possible but necessary.

In the next place the bed of Lake Ontario lies nearly 500 feet below that of Lake Erie, and as the change now in view would not lessen this amount by more than 150 feet, it is evident that no difficulty will be introduced to prevent the flow of the river from the latter into the former, and it only remains therefore to consider the relative levels at that day of the Ontarian valley and New York harbour. The deepest part of the Ontarian valley in lat. $43\frac{1}{2}°$ now lies, as we have said, at more than 200 feet below the surface of the Atlantic. The three degrees of latitude between the two points correspond to an elevation of 630 feet. This would place the Ontarian valley about 400 feet above the mouth of the Hudson, and supply ample fall for the river in its course of about 400 miles between the two points.

It must not be supposed that the figures above given are strictly accurate, accuracy being unattainable in the present state of our knowledge. They are only intended to show that there is no difficulty, when all the facts and probabilities are taken into account, in maintaining that in later Tertiary times a pre-glacial Mohawk, greater than the present river, drained the Huron valley and flowed through the gorge of Detroit into the vale of Erie. Taking its course to the north-east it received tributaries, among them the Maumee, the Rocky River, and the Cuyahoga, and passed through a chasm not far from the present

Niagara, probably forming a series of Rapids into the Ontarian plain. After traversing this from west to east, it escaped through the buried channel at Oswego, which it followed along the course of the present Mohawk until it reached the Hudson, then perhaps the smaller stream, and both united entered the Atlantic at some point south-east of where New York now stands.

One other point deserves a passing notice, but, for want of exact knowledge, it can only be at present an indication of probability. A striking feature in the geology of Canada is the great Silurian escarpment, as it is called. It consists of a range of cliffs, in some places two or three hundred feet high, commencing on the west bank of the Hudson, and forming the southern boundary of the valley of the Mohawk. Thence extending nearly due west to Niagara it sweeps round the western end of Lake Ontario to Cabot's Head, the Manitoulin Isles and Mackinaw, and skirts the western shore of Lake Michigan.*

This escarpment faces the north, and forms, at present, an imperfect division between Lake Huron and the Georgian vale. But when elevated, as in the later Tertiary age, it must have formed a water-shed between the Huronian valley and that in which now lie the waters of the Georgian Bay; and the question arises, in what direction did the waters of the Georgian valley then flow? A study of the geography of the country leads to the suspicion that they may have found their way to the eastward by the valleys of the present Severn and Trent and the Bay of Quinté. Sir William Logan, writing on this subject in the Geology of Canada, 1863, pp. 12, 13, describes a ridge of drift material running nearly east and west, at a short distance from Lake Ontario, and dividing the Lake Basin from the valley of the Trent or Ottonnabee. "Between the Holland and the Humber, Mr. Tully in his report on the proposed Georgian Bay canal, states the height of the ridge to be 904 feet above the sea. To the east of this it is crossed by the Toronto and Simcoe

* It appears as if geologists who advocate the excavation of the basins of the great lakes by the action of northern ice flowing off the Laurentian highlands, are somewhat oblivious of the existence of this escarpment. If the ice possessed the enormous eroding power on rocks and cliffs so often attributed to it, it must certainly have cut away and destroyed this gigantic barrier to its advance before proceeding to scoop out deep basins to the southward.

railroad, while to the west where it abuts against the Upper Silurian escarpment, and separates the Humber from the Nottawasaga, its height is 950 feet."

"Lake Simcoe is a tributary to Lake Huron, and lies 704 feet above the sea, but the depression in which it is situated is a continuation of the valley of the Trent, which can thus be traced from the Georgian Bay to Kingston."

"If the palæozoic rock surface beneath the drift ridge presents the same character as it does in other parts of the plain, it seems probable that it rises with a pretty even slope from the exposures on the lake to those north of it in the latitude of Peterborough, and that a depression accompanies the softer deposits from the Georgian Bay to Lake Ontario. This would give a probable depth of 400 feet to the drift along the chief part of the ridge, and a still greater depth over the depression."

Now Lake Simcoe, lying 704 feet above the sea, is only 130 feet above the level of Lake Huron, and if, as Sir Wm. Logan supposes, the rock lies more than 400 feet below the surface, it is evident that before the deposition of the drift, the waters of the Georgian valley may have flowed eastward along the depression where now lies the chain of Lakes Simcoe, Balsam, Cameron, Sturgeon, Mud, Salmon Trout, and Rice, and the present river Trent into the Bay of Quinté, at the eastern end of which they may have entered the Ontarian valley, and the pre-glacial Ottonnabee may have been a tributary of the pre-glacial Mohawk.

These are some of the changes which the elevation of the northern part of the continent before the deposition of the drift, probably implied, but we can trace them somewhat further. Three-fifths of the great system of fresh water lakes have already disappeared from our Tertiary geography, and it is evident that the same elevation will efface the most beautiful river of the continent, the St. Lawrence.

The St. Lawrence, at Quebec, is much farther to the north than Lake Ontario. The elevation due to its latitude, at the same rate as before, must have placed it at the time in question about 1300 feet above the Atlantic, while Montreal and Kingston were nearly 1000 feet above the same level. Instead therefore of flowing to the north-east the drainage of the waters of the district must have taken a south-westerly direction, and in all probability passed by some channel across the great plain between the St. Lawrence and the Green Mountains, not far it

may be from the course of the present Richelieu, into the valley of Lake Champlain and thence into the Hudson River, at that time a tributary to the Mohawk. At the present day the distance between the Hudson and the Lake is only "20 miles, with a height of land between them only 120 feet above the sea." Geology of Canada, 1863, p. 8.

Without taking into account therefore the layer of superficial deposits of which this height of land in part consists, it is easy to see that the course here suggested was then a more probable outlet for the Canadian waters from the north-east than that which they now follow. Those to the west of Montreal may have taken a course to the westward, and have entered the Ontarian valley near its eastern end, and become tributary to the Mohawk before it entered the Oswego chasm.

In order to show that the phenomena of the adjoining lakes, Michigan and Superior do not conflict with the results that we have thus far obtained, it may be well to refer to them for a moment. The bed of Lake Superior now lies about 200 feet below the Atlantic. It must therefore at the time and with the elevation in question have been more than 1300 feet above it. Moreover the researches of the Michigan Geological Survey have disclosed the existence of an old channel now filled with drift-clay and sand reaching southward from the south shore of the lake. The facts connected with the discovery are thus given by Mr. N. H. Winchell in a paper on the glacial features of Green Bay in the Am. Journal of Science and Arts for July, 1871:

"If we examine the south shore of Lake Superior we find that in a line directly north of little Bay de Noc occurs the only break in the otherwise continuous rocky barrier."

"From the mouth of the Chocolate River, six or eight miles east of Marquette to a point one mile and a half east of the mouth of the Train River, the shore is low and occupied by drift deposits, the usual rocky barrier of sandstone being interrupted or entirely wanting. Both to the east and to the west from this interval the shore of the lake is formed by the rocky ramparts either of the Lake Superior sandstone on the east or of the Huronian and other Eozoic rocks upon the west."

"In relation to the country between the head of little Bay de Noc and the shore of Lake Superior, we may infer that a valley exists or did exist connecting Lake Superior with Lake Michigan through little Bay de Noc, and that the present outlet of

Lake Superior is of comparatively recent date. Not only do the descriptions of this tract by Messrs. Foster and Whitney confirm this inference, but examinations of the district since made by Mr. Wadsworth of the Michigan Geological Survey, almost directly demonstrate the former outlet of Lake Superior to have been through the White Fish valley." "It appears that the outlet of Lake Superior was through little Bay de Noc up to the close of the Tertiary age." Of course we are as yet unable to give the depth of this channel, but considering the change of elevation it is not improbable that we have here the pre-glacial outlet from the valley, and that Lake Superior then existed as a vast, open, almost level plain, through which flowed a river to the southward. We incline however to think that instead of leading into the valley of Lake Michigan, as Mr. Winchell supposes, this river flowed more to the south-westward, through Lake Winnebago and Lake Horicon by the valley of Rock River, and met the Mississippi near where Rock Island now lies. In confirmation of this view we cite the following:

"The State of Wisconsin is traversed by a remarkable valley. Commencing north of Lake Michigan, near Lake Superior, this depression runs south west, and contains in its northern part the waters of Green Bay, and in its southern portion those of Rock River. It pursues an almost straight course for 400 miles and terminates on the Mississippi, where Rock River flows into it. From the northwest the country descends by a gentle slope into the valley, but from the south-west it breaks down suddenly and often by a perpendicular precipice. A rocky ridge, the Upper Silurian escarpment spoken of above, or rather an elevated region of Silurian rock, some 300 feet in height, separates this valley from Lake Michigan." E. Andrews, M.D., in Am. Journal of Science and Arts for September, 1869.*

The condition of the Michigan valley during the same era was similar to that of the valley of Lake Superior. In the geology of Ohio (Vol. 2, p. 13), we read: "An excavated trough runs northward" (*southward*) "from Lake Michigan to the north line of Iroquois county, Illinois, thence south-west through

* We may mention here that Mr. G. M. Dawson in his recent report on the geology of part of the region near the 49th parallel, states his belief that in pre-glacial times Lake Winnipeg also had a southern outlet.

Champagne county, beyond which it has not been traced. Its western margin is sharply marked at Chatsworth in Livingstone county, where it has a depth of 200 feet, and reaches the Cincinnati group. Farther north, its boundary walls are composed of Niagara limestone, and terminate in buried cliffs on the Calumet and Kankakee Rivers. At Bloomington this trough has a depth of 230 feet. . . . Where penetrated in other localities the depth of this channel is from 75 to 200 feet."

This channel leaves the basin of Lake Michigan near Chicago, where the land is now but few feet above the level of the lake, and its course appears to be marked out by a remarkable chain of forest oases in the prairies of Illinois, extending along the line indicated above. Whether, however, it reached the Mississippi directly, or indirectly through the valleys of the Wabash and Ohio, is not easy at present to determine. Further investigation along the line of the buried channel, can alone set at rest this uncertainty.

The depth of Lake Michigan may be set down at about 900 feet, and if we assume this and the greatest known depth of the buried channel at Bloomington as data, we find that, with the rate of elevation previously employed, the bed of the lake was 170 feet above the bottom of the buried channel. Here therefore we have an outlet by which the waters of the Michigan valley escaped into the great midland plain, and reached its draining stream, the Mississippi. In that event there was a river which may be named for the present the pre-glacial Michigan, traversing the long vale of the same name, narrower and deeper than those before described, and yet with sides sloping only about twenty-five feet in a mile.

Reviewing the results thus obtained, the early Quaternary Geography of the North American continent presents to the eye an appearance very different from that of the present day. The great river of the north-east was not the St. Lawrence but the Mohawk. Rising in the slopes of the wide and open Huron valley, it passed thence through the gorge at Detroit into the vale of Erie receiving tributaries on both banks. Thence it found its way through a similar gorge not very far from Niagara into the Ontarian valley, receiving on its way the waters of the Genessee, the Ottonnabee, and perhaps also of the Ottawa. It passed onwards through the deep and drift-filled channel under Lake Onondaga and the valley of the present Mohawk to the

valley of the present Hudson, and reached the Atlantic somewhere to the south-east of New York harbour, after a course of nearly 1000 miles, while its former tributary, the Hudson, appears to have drained the district whose waters now find an outlet to the Lower St. Lawrence. In the west the broad open vales of Superior and Michigan poured forth their waters to the south to meet the great Midland River of the Continent, the Mississippi, while the waters of the Georgian Bay instead of communicating, as at present, with Lake Huron, flowed directly into the Ontarian valley somewhere along the line of the present Ottonnabee.

From the position maintained in the present paper, several facts otherwise difficult of explanation, become consistent with one another, and are, in fact, necessary consequences of the principle here laid down. The great depth of the lakes to the northward is a result of the previous elevation and subsequent depression, which we have assumed as the basis of our reasoning. The almost uniform descent in the channel of the pre-glacial Mohawk from the valley of Lake Huron to New York harbour would be restored if elevation to the same amount should again take place and the accumulation of drift be removed. The shallowness of Lake Erie at its western end is a consequence of its southerly position which lessened the depression it has since undergone. It increases in depth to the north-east. Ontario is deeper than Erie, while the three upper lakes extending much farther to the north are also considerably deeper, because of the greater subsidence their basins have since experienced.*

Another fact which this principle explains is the excavation of many part of these channels below the level of the sea. The bottoms of lakes Superior, Michigan, Huron and Ontario, are all more than 200 feot below the surface of the Atlantic. The same is true of the buried channel under Lake Onondaga, and also t oa less degree of several places in the present Hudson River.

There is no evidence that cataracts ever existed to scoop out these basins, and with one exception no other agent has ever been brought forward to explain their formation. That agent is ice, and to it some writers are disposed to attribute effects which the evidence fails to support. We have already alluded to the

* A similar explanation may be given of the great depth of the bed of the Saguenay and the lower St. Lawrence.

opinions of Dr. Newberry as expressed in the volumes of the Ohio Survey. It seems necessary, however, to dwell on this point somewhat more fully in order to show that the theory of the origin of our lake basins here maintained is more consonant with facts than that which attributes it to the action of ice. Dr. Newberry says (1876, p. 74):

"There can be no doubt that the basin of each of the great lakes has been produced by a local glacier, and that the great ice-sheet which existed during the period of intensest cold, moving as a solid continuous mass of great thickness from north to south would have the effect to obliterate rather than to form such local troughs. Our lake basins must therefore have been formed before or after the continental glacier, or both before and after. Probably the latter is the true statement of the case."

The central and eastern portions of the bed of Lake Erie were once occupied by soft rocks. Of these more than 1000 feet in thickness were removed. To this enormous erosion by the ice, to which Dr. Newberry evidently ascribes the origin of the Erie valley, the following passage from the same volume suggests a serious objection: "An interesting fact was noticed by Mr. Gilbert, Mr. Winchell and myself, that in the north-west portion of the State, a series of glacial markings which have a nearly north and south bearing are obliterated (*nearly* obliterated ?) by the stronger, fresher, and more numerous grooves of which the bearing is nearly east and west."

The north and south grooves, to which Dr. Newberry here refers, are of course those attributed to the continental ice-sheet, while the east and west grooves of later date are those caused by the local glacier which followed it as the ice-sheet dwindled away. We cannot agree, however, with Dr. Newberry's reading of this natural palimpsest, for it appears highly improbable that the excavation of the lake basin was principally effected by this local east-west glacier, which was evidently unable to remove the superficial scratches left by its larger predecessor.

All will agree, we think, with Dr. Newberry that the effect of the great ice-sheet would be to obliterate rather than to form such local troughs. But even this planing effect seems greatly overrated. There is no proof that the great ice-sheet has removed more than an inconsiderable layer of the superficial rock of the region. Why then, we may ask, should a local glacier be supposed able to excavate so deeply rocks on which the great

continental glacier produced so small an effect? In short we have as yet no evidence that either local glaciers or a continental ice-sheet could excavate the basins of the great American lakes. The effect seems more justly attributable to the slow action of a river during part or the whole of the Secondary and Tertiary eras.

The three lakes, Huron, Erie and Ontario, are therefore on the view here maintained, only the broad portions of the valley of an ancient river, the narrow parts of whose channel were filled up with drift during the glacial era. A glance at the geology of the region confirms this view. The western end of Lake Erie lies on the hard Corniferous limestone, but the greater part of the lake basin is excavated out of the Hamilton and Erie shales, which are comparatively soft. At the eastern end of the lake the Upper Silurian ridge of Niagara limestone crosses the course of the river. The Ontarian basin also is cut out chiefly in the Hudson River shales, while hard rock again ensues between it and the sea. Accordingly we have the gorge at Detroit in the hard limestone, the broad open valleys of Erie and Ontario in the softer shales, and the channel at Niagara between them, worn in the Upper Silurian limestone. It is easy to see that the rate of erosion in the softer rocks must have been limited by the rate at which the hard limestone barriers could be cut down. The river meandered, as is usual with rivers, hither and thither over the wide plain, gradually excavating the valley by cutting down and carrying away the material as fast as the rocky bars were lowered. And when the length of time during which the work may have been in progress is considered, no one familiar with the phenomena of subaerial erosion will deem the cause insufficient. Let any one who doubts reflect on the examples to be found in other parts of the world. Let him turn to south-western Ohio, and see how the hard Niagara limestone has been swept away over a wide district, where existing outliers prove that it was formerly present, and by rivers of comparatively insignificant size—the two Miamis and their tributaries. Let him also realize how large a lake would be formed by damming back the Ohio at Cincinnati with a mole one or two hundred feet in height, and we think all difficulty will vanish in admitting the erosion which we here imply, vast as it is, during the time that elapsed from the Carboniferous to the Quaternary era—that is during the whole Secondary and Tertiary ages.

The scenery along such a river presented alternately the low wide landscape of the open plain and the deep contracted view of the narrow pass, each passing into the other, as the underlying rocks change from soft to hard or from hard to soft. The spread of drift-material over the face of the country left the narrow gorges completely choked. As the rivers began again to flow after the ice-age had passed away they were unable to find their ancient channels along these narrow chasms, and consequently the water accumulated in the valley until it rose sufficiently high to flow over the barrier at its lowest point, when it commenced anew the task of cutting a gorge through the same limestone ridge, first in the drift material on the surface, and then in the solid rock below. This process may now be seen going on at Niagara Falls.

The great American lakes therefore are nothing but mere drift-dammed pools, filling the wide portions of the channels of pre-glacial rivers, while the narrow chasms connecting them are concealed by superficial deposits of clay and sand. Should the present condition of things continue long enough, the rocky barrier between Erie and Ontario will be again cut down, and the present lake above the Falls converted again into the broad open plain of the later Tertiary age. New falls or rapids will be developed near Detroit as the excavation of the Erie basin proceeds, and the levels of lakes Huron and Michigan correspondingly lowered; while by the gradual wearing down of the rocky bars now forming the rapids on the St. Lawrence, as much of the water in Lake Ontario will be carried away as the relative levels of that lake and the Atlantic will allow. But neither Michigan, Huron, nor Ontario can ever be laid dry by this process, and their end can only come, catastrophes excepted, by the slow but steady process of silting up. The same process to some extent must occur in Lake Superior. The wearing down at the falls of St. Mary will lower its level, but the deposit from its tributary streams alone can entirely obliterate it.

One result of the Quaternary age has therefore been to transfer a great part of the basin of the pre-glacial Mohawk to the basin of the St. Lawrence, a younger and Quaternary river. But no great alteration in level would be required to change again the course of these northern waters. The sewers of Chicago now carry the water of Lake Michigan into the Mississippi valley, the watershed between the two being only 10 feet above the

lake, or about 23 feet above Lake Erie. Evidently, therefore, a very slight rise in the bed of Niagara river would raise the level of the three lakes and cause their waters to flow south-into the Mississippi rather than north-east into the Atlantic.

But great as these changes in the physical geography of the country appear, they are geologically trifling. The general surface was then as it is now. No new mountains have risen, and little progress has been made in the destruction of old ones. The great midland valley extended from the Alleghany Mountains westward, and was drained by the Mississippi, the Father of Waters in age not less than size. The Adirondacks, the Laurentides, the Green and White Mountains, the Catskills, and the Helderberg range then stood as now, while along the eastern border of the Continent the Alleghanies and the Blue Ridge formed its Atlantic frontier, their western slopes being drained by the Ohio and its tributaries, flowing at least a hundred feet below their present level.*

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* The substance of this paper was delivered before the Cincinnati Natural History Society in January, 1875, and illustrated by a map which is not reproduced here. The argument however appears intelligible without its aid.

NOTES ON THE APPEARANCE AND MIGRATIONS OF THE LOCUST IN MANITOBA AND THE NORTH-WEST TERRITORIES—SUMMER OF 1875.

By George M. Dawson, Assoc. R.S.M., F.G.S.

From the reports now received from Manitoba and various portions of the North-west Territory, and published in abstract with these notes, it would appear that during the summer of 1875 two distinct elements were concerned in the locust manifestation. First, the insects hatching in the Province of Manitoba and surrounding regions from eggs left by the western and north-western invading swarms of the previous autumn; second, a distinct foreign host, moving, for the most part, from south to north. The locusts are known to have hatched in great numbers over almost the entire area of Manitoba, and westward at least as far as Fort Ellice on the Assineboine River (long. 101° 20′), and may probably have been produced, at least sporadically, in other portions of the central regions of the plains; though in the summer of 1874, this district was nearly emptied to recruit the swarms devastating Manitoba and the Western States, and there appears to have been little if any influx to supply their place. Still further west, on the plains along the base of the Rocky Mountains, from the 49th parallel to the Red Deer River, locusts are known to have hatched in considerable numbers—but of these more anon.

Hatching began in Manitoba and adjacent regions in favourable localities as early as May 7th, but does not seem to have become general till about the 15th of the month, and to have continued during the latter part of May and till the 15th of June; while, according to Mr. Gunn and others, in cold clayey land and where pools of water from the melting of the snow lay long, isolated colonies came out at still later dates. Mr. Gunn states that grasshoppers were even noticed to hatch in August and September, in spots which had been covered with water all summer, a fact showing the very persistent vitality of the eggs, and apparently negativing opinions which have been expressed as to their destruction by damp. The most northern locality at which locusts are reported to have been produced from the egg, is at Manitoba House, Manitoba Lake.

The destruction of crops by the growing insects, in all the settled regions was very great, and in many districts well nigh complete. The exodus of these broods began in the early part of July, but appears to have been most general during the middle and latter part of that month, and first of August. The direction taken on departure was, with very little exception, south-east or south. It is to be remarked, that as there does not seem to have been during this period any remarkable persistency of north-west or northerly winds, the insects must have selected those favouring their intended direction of migration, an instinct which has very generally been observed elsewhere. Though most of the parents, in 1874, came from the west and north-west, and Manitoba must have represented to those ending their flight there, the south-eastern limit of their range; the young insects of 1875 thus took a south-eastward direction, just as though starting from their usual breeding-grounds in the far north-west, and showed no disposition to return to the region whence their parents came. This direction of flight carried many of the insects at once into a country of thick woods, swamps, and lakes; and caused the repetition of the phenomenon of the appearance of grasshoppers in great numbers about the Lake of the Woods, a circumstance only once before noted—in the summer of 1857.* This previous occasion however differed from that of last year in being an extension of an invasion of Manitoba from the west or north-west, and not resulting from insects hatching in that province.

It is probable that most of the grasshopper swarms of Manitoba, thus entering the wooded country, were there harmlessly spent, for though some northern swarms reached the State of Minnesota, the invasion appears to have been comparatively unimportant. Northern swarms are noted to have passed over Crookston (Polk County, Minnesota), and Fort Totten, (Dakota); the greatest number appearing at the latter place July 19th. The locust swarms described by Mr. Riley † in the following paragraph, from information furnished to the *Chicago Tribune*, dated July 13th, probably also came from Manitoba: "The first foreign hoppers appeared on the Sioux City Road, alighting be-

* Not 1867 as erroniously printed in Notes for 1874.

† From Mr. Chas. V. Riley's very interesting Eighth Annual Report on the Noxious, Beneficial, and other Insects of the State of Missouri.

tween Lake Crystal and St. James on Wednesday last. A few days later they were observed at New Ulm flying south-east, and at noon of the same day struck the line of the road at Madelina, St. James, Fountain Lake, Windom, and Heron Lake, covering the track for about 50 miles of its length." It will be observed on referring to the summary on another page, that the insects produced in Minnesota itself flew south-west in the early part of July.

I have not been able to trace further the movements of these Manitoba broods, unless indeed it be supposed that some at least of the swarms which passed over central Illinois early in September, came from that quarter. These, however, Mr. Riley believes not to have been the true migratory locust—*Caloptenus spretus*.

Foreign swarms from the south crossed the 49th parallel with á wide front stretching from the 98th to the 108th meridian, and are quite distinguishable from those produced in the country, from the fact that many of them arrived before the latter were mature. These flights constituted the extreme northern part of the army returning northward and north-westward from the states ravaged in the autumn of 1874. They appeared at Fort Ellice on the 13th of June, and at Qu'Appelle Fort on the 17th of the same month, favoured much no doubt by the steady south and south-east winds, which according to the meteorological register at Winnipeg, prevailed on the 12th of June and for about a week thereafter. After their first appearance, however, their subsequent progress seems to have been comparatively slow, and their advancing border very irregular in outline. They are said to have reached Swan Lake House—the most northern point to which they are known to have attained—about July 10; while Fort Pelly, further west, and nearly a degree further south, was reached July 20th, and about seven days were occupied in the journey thence to Swan River Barracks, a distance of only ten miles. It is more than probable that the first southern swarms were followed by others, which mingled with them, or even, in parts of Manitoba and the country immediately west of it, with the indigenous brood. From a few localities only, in Manitoba—and those in its western portion—is the evidence pretty conclusive as to the arrival of foreign swarms from the south. Burnside, Westbourne, Portage La Prairie, Rockwood, and Pigeon Lake, may be mentioned as affording instances.

Many of the grasshoppers observed, according to reports received by Mr. Riley, in Dakota, at Fort Thompson, Yankton, Fort Sully, Springfield, Fort Randall, and Bismark, flying northward and north-westward at various dates in June and July, no doubt eventually found their way north of the 49th parallel. Those seen at Bismark about June 6th and 7th, probably belonged to the earliest southern bands above referred to, and judging from the dates given by Mr. Riley, may have been produced in Nebraska, or more probably even still further south. A portion of the southern and eastern army probably reached Montana, and may even have penetrated in diminished numbers into the districts in the vicinity of Bow River.

A considerable number of locusts appear to have hatched at about the same date as in Manitoba, near the extreme western margin of the plains, especially in the country near Bow River. Foreign swarms arrived at Fort McLeod from the south-west, depositing eggs; and most of those hatching near Bow River, and further north, seem to have gone south-eastward early in August. No very definite or wide spread movement of swarms appears, however, to have occurred during the summer of 1875 in this region, nor, if we may judge from the very meagre accounts received, in the corresponding portion of Montana.

The following notes, representing the condition of affairs in the Western States and Territories, south of the 49th parallel, are abstracts of the accounts in Mr. C. V. Riley's work, already referred to, and will serve as a basis of comparison:

Texas and Indian Territory. Hatched in large numbers early in spring in Texas and Indian Territory. Left in May, and early in June, going for the most part north

Kansas. Ravages confined to districts 150 miles long, 50 broad, along eastern border of State, this being the region where most eggs laid in 1874. Hatching from April 6th to May 10th. Flew north-west in latter part of May and first week in June.

Colorado. Hatched pretty generally over the territory, appearing from early in May till July, according to elevation. Prevalent direction of flight on departure south and south-east.

Nebraska. Hatching ground limited to districts bordering Missouri River. Insects produced early in May, and began to fly northward about June 7th. Several swarms from more southern regions passed north-westward over the State before those hatching here took wing.

Missouri. Hatched early in May, especially in the middle western counties. Began leaving early in June, the majority departing about the middle of the month. Main direction of flight, north-westward.

Iowa. Locusts hatched in a few localities near the south-west boundary of the State. From the 10th of June to the middle of July western counties suffered from swarms passing from south to north.

Minnesota. Hatched pretty generally throughout western part of State. Some appeared as early as April and were killed by cold and wet. The majority left early in July, and appear to have gone south-westward.

Dakota. Known to have hatched near the southern boundary of Manitoba. These insects, and those from further north, went southward early in August. During June, and in August, foreign swarms passed over the State going north-westward.

Montana. Some probably hatched here, and swarms from the east and south-east appeared during July.

During the summer of 1875, the conditions described in the Notes for 1874 as occurring in the region west of the 103rd meridian, were reproduced in Manitoba, and over a great area of the Western and South-western States, with results even more disastrous to the crops than those of the winged invasion of the previous year. We do not hear of any access of fresh swarms to Manitoba from the west or north-west, nor is it probable that any such occurred, notwithstanding the fact that in various parts of the province flights are reported to have passed over from north-west to south-east. From the dates and descriptions given, it seems certain, that these were only those from the more remote parts of the province itself, and in many cases the broods hatched in any locality mingled with those coming from a little distance, and departed at the same time.

The most remarkable and exceptional feature in connection with the appearance of the locusts in 1875, is the extensive invasion of the wooded region east of Manitoba by the swarms produced in the Province. This is the more noticeable when contrasted with the immunity enjoyed by Prince Albert on the Saskatchewan, alluded to in last year's Notes, which is owing to its separation from the general area of the plains by a belt of timber. On writing to Mr. Clarke of Carleton House on the subject, he informs me that this protecting belt of "fir timber"

is only four miles in width, and extends completely across between the north and south branches of the Saskatchewan. Judging from the above remarkable fact, and the known habits of the locust, I do not think that the incursion made into the forest country can be looked upon as anything but exceptional, and perhaps showing that the locusts had lost their reckoning. Nor do I believe that it should discourage the cultivation of belts of woodland, which promises to effect in time a general and permanent amelioration of the grasshopper plague.

Broadly sketched, the movements of the locust in 1875 conform to a general plan. All those hatching in Minnesota, Manitoba, northern Dakota, and in the high western region of the plains at least as far south as Colorado, on obtaining their wings went southward, and this in some instances regardless of the direction from which their parents had arrived in the previous year. Swarms produced in Nebraska, Missouri, Kansas, Texas, and Indian Territory, flew northward and north-westward, returning on the course of their parents, which had flown south-eastward from that quarter. This movement can be traced over an immense area, from the northern borders of Texas almost to the Saskatchewan River.

Evidence appears to be fast accumulating to show that the general and normal direction of flight for any brood, is to return toward the hatching grounds from which their parents came, and it would thus seem, that to complete the migration-cycle of the locust, two years are required. The tendency which the swarms show to migrate on reaching maturity cannot be wondered at, as it is so commonly met with in other animals, and may be assisted by the mere lack of food in the district which has for a long time supported the young locusts. The fact however—let us call it instinct or knowledge—that the young, while amenable to the migratory tendency, show a determination to exercise it in a direction exactly the opposite of the preceding generation, is most remarkable.

No panacea against the grasshopper appears yet to have been found, nor does it seem likely that any such will be discovered. The means of making war upon the young insects and winged swarms, with a degree of efficiency dependent largely on the determination of the people, and density of settlement in the afflicted districts, are now well known. Though it is to be hoped that Manitoba and the settled portions of the North-west may

long escape further trouble from these depredators, it is none the less a duty to prepare for a possible repetition of the scenes which have already been witnessed there. In various portions of the United States, the destruction of the young insects has been greatly encouraged by the payment of bounties for that purpose from the public treasuries, but with a plague so widespread as that of the locust, the means most likely to lead to permanent amelioration are those capable of general application. The movement in the Western States toward the appointment of a commission by the central government to investigate all the facts connected with the locust trouble, and suggest means for its relief, is in the right direction; and if such a commission is appointed, it would appear to be of the greatest importance that Canada should take similar action, and at the same time, for its western territory.

By such general measures as the cultivation and preservation of forest trees, the protection of the prairie grass till the appropriate time for destroying the young insects in their hatching grounds by fire, and the encouragement of all birds feeding on the young or fledged, imsect, much may be done. The prairie chicken, and the various species of blackbirds, get the credit of devouring great numbers of the young grasshoppers, and if these were protected by more stringent laws, and even a small increase in safety to the crops resulted, the loss of the one as a game bird and the damage frequently done by the other in the cornfields, would be more than counterbalanced.

The point of prime importance however in the first instance, is to obtain a complete knowledge of the haunts and habits of the insect under discussion, and as a small contribution towards this end these notes are submitted.

Mr. G. M. Dodge of Glencoe County, Nebraska, has published a theory relative to the cause or motive of the migrations of the locust, in the *Canadian Entomologist* for 1875. Mr. Dodge has kindly favoured me with an explanation of this theory. He writes: "I find the insects to be double brooded, flying north in spring to rear a second brood in a region not already devastated. The resulting brood flies south late in autumn, and deposit eggs that lie over winter. This regular movement is complicated by the fact that if the insects of brood first, hatching as far north as this place, should fly north, their progeny might be destroyed by frost; consequently I find that all hatching here or further

north (of brood first) fly south to rear the brood second. I believe with yourself that their natural habitation is the plains east of the mountains, and think that their occasional invasion of the States is due to the prevailing winds." After giving several instances from Nebraska bearing on his theory, Mr. Dodge, referring to my Notes on the Locust Invasion of 1874, says: "In your items from various localities, I find a point that bears directly upon the double brooded character of the insect, but which may have escaped your notice. In the notes from Fort Ellice, Headingly, Rockwood, Scratching River, Winnipeg, Stone Fort, and St. Anne's, eggs are said to have hatched in autumn; and in *each case* grasshoppers are reported as coming from the *south* early in the season. These were of course of brood first; brood second coming always from a northerly direction would deposit eggs for the next spring's brood, and none of them would hatch in autumn."

I do not think Mr. Dodge's theory can be accepted in its entirety, though the locust may occasionally complete two generations in one season, when the circumstances would no doubt be as above supposed. Certain it is, however, that southern swarms seldom if ever reach the country north of the 49th parallel in time to allow a second brood to reach maturity, even if the eggs hatch in summer or autumn. The date of arrival of the first swarms in Manitoba in 1874 was considered exceptionally early, and yet it is believed that all their progeny hatching during the autumn were destroyed by frost.

The Hon. D. Gunn has favoured me with the following historical notes on the grasshopper, going back to the earliest settlement of the Red River country:

"The first appearance of the locusts in this land, of which we have any account, took place on the 18th of July, 1818, six years after the commencement of the colony. At that period of the season the wheat was well advanced towards maturity, and sufficiently strong to resist the voracious destroyers. But it fared otherwise with the barley. The locusts attacked the plants a few inches below the ear, and cut them off as neatly as if cut off by the hand of man with a pair of shears. However on this occasion nothing was lost; every ear that fell to the ground was carefully gathered up. The potatoes were injured to some extent, but all garden vegetables were devoured. Their eggs deposited, incited by instinct or pressed by hunger, they

departed. In the following spring the young locusts began to appear, and before the latter end of May, 1819, the whole country was literally covered with them, and the rising crops of every kind entirely devoured. These in due time left to invade some other region. The opinion of the settlers who were here at the time was that they flew to the north and were driven by a strong south wind into Lake Winnipeg and drowned in such great numbers that the waves heaped them up, in some parts of the western shore, to a depth of several feet. As soon as these had taken their flight, fresh swarms poured in from the south-west, but found nothing to devour but the stinted natural grasses of the plains, which their predecessors had eaten to the very roots. Notwithstanding the scantiness of their diet, they deposited their eggs in great numbers, which the warmth of the following spring ushered into life. At the usual time, the latter end of July and first week of August, they disappeared, and from 1820 to 1857 the country was free from the inroads of these formidable destroyers. In 1857 a considerable swarm of locusts visited the settlements on the lower Assiniboine in the latter end of July, but these did not extend in any considerable numbers towards lower Fort Garry. They deposited their eggs over what is now known as Headingly and White Horse Plain parishes, and in the spring of 1858 the young progeny destroyed the crops in the above-mentioned region, say a distance of twelve or fifteen miles. These after they attained their full growth, as usual left the country. In 1864 another invasion took place, great numbers of them fell on each side of the Assiniboine, and extended down to upper Fort Garry. On the 7th of July they flew in great numbers over the lower settlement. They were driven by a fresh breeze from the west, some of them appeared to be at a great height from the earth, the living mass extending downward to the height of a few feet from the surface. numbers of the lowermost falling continually to the ground. The foremost part of the cloud began to pass over this place at 10 a.m., and they continued flying for some time after 2 p.m., and during the time of their flight they had fallen in such numbers that from twelve to twenty were counted on a square foot of surface. After a short rest, those which had alighted on ploughed lands and on barren spots moved into corn-fields and began feeding on the leaves of the wheat plant, and according to their usual habit cut off the heads of the barley. Here I had an opportu-

nity of observing that, as a rule, they do not pass the night, under ordinary circumstances, on the ground, but climb upon pickets, fencing, and on every other object on which they can roost. On the tenth of July they were seen pairing and depositing their ova. In the first week of September they disappeared. In the beginning of May, 1865, the young ones began to appear. On the 9th of June, 1865, a swarm of locusts came from the south. They extended from the west side of Lake Manitoba to Fort Alexander on the east. They fell in great numbers in that lake and on its eastern shore, but were very sparsely scattered over the country to the east of the above body of water. However those which were hatched in the spring, and those that came in June did not seriously injure the growing crops, and the farmers reaped an abundant harvest. In 1867 the locusts made their appearance in very great numbers, but came about the beginning of August, and consequently did not do much injury to the wheat crops, but many of the farmers had hard work to save the barley and oats. These, according to their habit, deposited their eggs in great numbers, and departed to die in some other place, either to the east or south-east of this place. The river ice began to break up on the 24th of April, 1868, and on the 7th of May I took the following note: 'Grasshoppers moving about, color pale white, not much bigger than fleas.' On the 22nd of the same month their numbers had greatly increased, and some had become brown. They evidently continued coming out of the ground during the whole month of May, and a few perhaps during the first ten days of June. All the grain of every kind that was growing was eaten up by them before they took their departure, which was in the end of July and during the first week of August. After this none were seen until 1872, when on the 5th of August they appeared. By the 12th they had become very numerous, and on the 14th they were depositing their eggs. In the first week of September many of them had taken their departure, and all disappeared by the last of that month. Their offspring began to appear about the middle of May, and by the middle of June the whole country was literally covered with them, no grain had been sown, the potatoe vines had been consumed, and even the pasture on the plains suffered greatly from their ravages. However they left about the usual time. The next and last visitation we had from these living plagues was in July, 1874. On the 17th immense

swarms for some hours flew over the city of Winnipeg; at the same time thousands of them were coming to the ground. In a few days after they extended their excursion to Lake Winnipeg, but numbers of them left before they had deposited their eggs. Yet millions of eggs were deposited, but as the last spring, 1875, was very late, the ground kept cold during the most part of the month of May, the locusts were very late in being hatched; some made their appearance about the 10th of May, and others as late as the last week in that month. They were numerous in some places; however I am of opinion that if the people had made a combined effort to destroy them during the first and second weeks of their existence, could not have failed in destroying many of them, and would by so doing, had they sown or planted, have raised both wheat and potatoes. Most people however became discouraged, and could not be persuaded to make the least effort to rid the land of the plague."

I have to thank the various gentlemen who have kindly replied in answer to my circular asking information, and beg to suggest that in all cases of the appearance of the locust, careful notes be kept as to dates, directions of flight, &c.

In the subjoined digest of the more important items received from the various localities, the places are arranged in order from west to east.

Fort McLeod, North-west Territory. (R. B. Merritt, M.D.) No young insects observed. Foreign swarms arrived July 19th from the south-west, and continued passing, or on the ground—though most of them went on—till about August 25th; went north-westward. Eggs were deposited and some known to have hatched in the autumn. No cultivation here, but 25 per cent. of prairie grass eaten. Mr. Merritt adds: "In April, 1876, many young black hoppers seen around Fort McLeod. On my trip from Bow River, I saw a tract of country 70 miles wide covered with young grasshoppers. They appeared to be eating the grass, and only moving when disturbed."

Morleyville, Bow River, N. W. T. (J. Macdougall.) Produced here from the egg, hatching May 20th. Left in August going southward. A great swarm arrived on the wing from the northward about August 10th, the main body passed overhead

in about six hours going southward, while some remained several days on the ground. Some eggs deposited. Crops, represented by a small patch of potatoes, were not hurt.

Bow River, N. W. T. (J. Brown.) Produced here from the egg, hatching about the first of May; flew south-eastward from Oct. 1st to 15th. Winged swarms arrived late in July or about first of August, from the north and north-west, passing on for the most part, but depositing some eggs. The small quantity of crops put in were lost. Wild grasses in many places much injured, though bunch-grass of mountains untouched. Eggs hatched spring of 1876, and insects on July 25th almost ready to fly.

Plains between Fort McLeod and Edmonton, N.W.T. (Rev. Constantine Scollen.) Produced in large numbers from the egg, hatching about June 1st. Left toward the latter part of August, going north and north-east. Great swarms appeared on the wing from the south and south-west August 1st, some alighting and others continuing their flight. Continued arriving till August 15th, and departing north and north-east, those produced in the country accompanying them. Eggs deposited during latter part of August, none known to have hatched in autumn. Ma. Scollen adds: "I may remark that the grasshopper during the last four years it has visited this country, has always come from and gone on in the same direction. They have always stopped about 60 miles south of Edmonton, perhaps owing to the densely wooded country in that vicinity." No cultivation in this region.

Edmonton, N. W. T. (R. Hardisty.) The locust did not appear here. Mr. Hardisty writing from an experience of twenty years, states that he has never known the insect to appear at Edmonton, though he has often seen them in large numbers about fifty miles south of that place. Edmonton is about forty miles from the northern edge of the plains, and separated from them by country *well wooded* with small poplar and pine, and having many small lakes, and swamps with strong heavy grass.

Country between Battle and Red Deer Rivers, N.W.T. (W. McKay.) Grasshoppers did not appear in this region during the summer of 1875.

Bozeman, Montana. (J. Wright.) Not produced from the egg. Arrived on the wing, appearing first on the 8th of July, but continued passing overhead in large swarms from the east for some time.

Victoria, Saskatchewan, N.W.T. (Chas. Adams.) Did not appear here.

Carleton House, N.W.T. (L. Clarke.) Did not appear in this vicinity. Mr. Clarke writes: "From traders I have learned that grasshoppers appeared in great numbers about 130 miles to the south-west of Carleton. Again, they were seen to the south-east of Touchwood Hills as far east as Fort Pelly, destroying the crops at that station.

Touchwood Hills Post, N. W. T. (R. W. Ells, Geological Survey of Canada.) Not produced from the egg here, but arrived on the wing, flying north-west. Very numerous July 30. Mr. Ells did not see any grasshoppers west of the Touchwood Hills.

Fort Qu'Appelle, N.W.T. (W. J. McLean.) Not produced here from the egg. Full grown insects appeared in myriads, June 17th, coming from the south.

Fort Pelly, N. W. T. (A. McBeath.) Not hatched here. Swarms arrived on the wing, July 20th, from the south, and passed on northward. All crops destroyed. Eggs deposited, and none hatched in autumn. Mr. McBeath writes,—After the grasshoppers made their appearance here on the 20th of July, their progress was very slow. The Mounted Police barracks are some ten miles north of this place, yet they took two weeks to reach there. For a time it appeared that this place was the end of their journey, and they diminished very slowly. Many were killed by the frost. As far as I could learn they did not go further north than about 30 miles from here. Shortly after their arrival they began depositing their eggs, and dying, till the ground was covered with their dead bodies.

Swan River Barracks, Pelly, N.W.T. (lat. 51° 53′, long. 101° 59′. J. H. Kittson, M.D.) Not produced here, arrived on the wing July 27, from the south. Continued passing till Aug. 20, going in a direction north-west by north. Some remained, and eggs in considerable quantity deposited. Late in autumn insects remaining after depositing eggs were destroyed by small red parasites.

Fort Ellice, N.W.T. (A. McDonald and R. W. Ells.) Produced here from the egg, hatching about May 6th. By June 7th all growing crops destroyed. Left in the beginning of

August, going south-east. On June 13th swarms arrived on the wing from the south or south-east, and at once began to deposit eggs. The first that arrived did not remain long on the ground. A second swarm arrived on the 10th of July, and about two days afterwards a third lot appeared. These also deposited eggs, the last remaining till the beginning of September. All crops destroyed—oats and barley. No eggs hatched in autumn. Mr. Ells writes that eggs were deposited at Fort Ellice as early as the 20th of June.

Swan Lake House, N. W. T. (D. McDonald.) A few locusts observed to arrive on the wing about July 10th, coming from south by south-west. These appear to have deposited some eggs which hatching in September produced young insects which were either frozen, or took flight August first, in a direction between south and east. No crops destroyed, the locusts having arrived late and in small numbers.

Manitoba House, N. W. T. (J. Cowie, J. P.) Produced here from the egg, hatching about June 9th. Left about the end of July, going north. Swarms also arrived on the wing, some remaining on the ground, and some passing over. From the middle of June till the end of July they came with every south-east wind, the latest remaining altogether, the earlier swarms going north. Mr. Cowie writes: "The young before taking wing marched through the settlement from S. to N., and destroyed all the crops except potatoes. Some returned on foot going south, and some remained until able to fly."

Fort Totten, Dakota. (Dr. J. B. Ferguson.) No locusts hatched here. Foreign swarms appeared July 19, coming from the north, and departing finally about July 22 or 23; going southward. Little damage done to crops. No eggs deposited. Dr. Ferguson writes:—The 19th of July is the date when locusts first appeared here in large numbers and alighted on the ground. Swarms were seen passing over before this date, but no note made of the exact day. Those that came on the 19th remained 3 or 4 days, and then left. It rarely happens that a swarm passes without some coming down, while others already here appear to rise and join them in the air. In this way even after the great body of locusts has passed, considerable numbers remain behind, and do not entirely disappear for from 10 to 12 days, and sometimes even longer.

Woodside, Man. (Thos. Collins) Produced here from the egg, hatching from about the 20th of May till the end of June. Most took their departure about the middle of July, but a considerable number remained till the first week in August. Went south-eastward. A winged swarm arrived from west-north-west about the third week in July; remained a short time and departed south-eastward. Whole grain crop destroyed, estimated at 6,700 bushels for Woodside, Pine Creek, and Squirrel Creek. A few potatoes escaped. Very few eggs deposited.

Westbourne, Man. (P. Garriock.) Produced here from the egg, hatching from the 10th to the 15th of May. Began their departure about 1st of July, and continued leaving till some time in August, going south-east. Great swarms were observed at two or three different times, many alighting, while the rest passed on. These arrived about the first of July, coming as a rule from the north-west and going south-east. Disappeared during latter part of July and first of August. Grain crop would probably have amounted to 4000 or 5000 bushels, but all destroyed except about 50 bushels. Few eggs deposited. Mr. Garriock writes:—Some time in the beginning of June, if I remember rightly, great swarms of grasshoppers, quite different in colour and size from all that had ever visited this country, came from due south, and passed on to the north-west. Great numbers alighted, but after remaining but a few hours, they rose again, and followed the main body. They appeared to us to be a very peculiar species of the detestable grasshopper, in size at least one-third larger than the pest with which we have become too well acquainted, and of leaden colour.

Burnside, Man. (K. McKenzie.) Produced here from the egg, hatching from the 10th to the 24th of May on warm sandy ridges, from that date till the middle of June in heavier cold soils. Left from July 8th to about first week in August, disappearing gradually, but generally going east or north-east. Winged swarms arrived in July, and for the most part passed overhead. Came from west or south-west, and left generally eastward. A few arrived on the wing during the first week in June. In Palestine district whole crop destroyed. In Portage, High Bluff, and Poplar Point districts, about 40,000 bushels of grain harvested, probably about one-tenth of the crop. Potatoes gave about one-fourth crop. No eggs deposited here. Mr.

McKenzie says it is reported that eggs were deposited west of Manitoba Lake, about one hundred miles north-west of Burnside.

Portage la Prairie, Man. (C. Mair, J. Cowan, M.P.P.) Produced here from the egg, hatching from the middle of May to middle of June. Began to leave about middle of July, going south-east. Winged swarms passed overhead from the latter part of July till the middle of August, coming generally from the south-west and going south-east: few alighted. Two-thirds to four-fifths of crop destroyed. In Portage la Prairie, Electoral Division, about 12 miles square, the grain crop should have been 200,000 bushels; 40,000 bushels actually harvested. In High Bluff Electoral Division, loss greater in proportion, only 10,000 bushels of grain saved and a half crop of potatoes. Mr. Cowan writes that some winged swarms appeared from the south early in June, long before those hatched here could fly.

High Bluff, Man. (J. A. K. Drummond) Produced here from the egg, hatching May 15th to June 15th. Left about the middle of July, going for the most part south-east. A winged swarm arrived from the west July 19th, and swarms continued arriving from this direction, and departing, generally south-eastward till the latter part of August. Greater part of crops destroyed. No eggs deposited.

Gladstone, Man. (C. P. Brown.) Produced here from the egg, hatching June and July. Left about the last of August, going south-eastward. About July 17th a few winged swarms arrived from the west, leaving in same direction as those produced here. Crop, amounting to from 20,000 to 30,000 bushels destroyed. No eggs deposited.

Poplar Point, Man. (L. W. McLean.) Produced from the egg, hatching from the 20th of May till the 10th of June. Took flight about the 2nd of July, and continued flying till the 10th of August or thereabout; went south-east. Some swarms seen on the wing at dates above given were supposed to have hatched in the western and north-western parts of the province, or beyond the province line. These appear to have mingled with those produced in the locality itself, in their flight. Only crops planted, potatoes, which generally gave pretty good returns. No eggs deposited.

Oak Point, Manitoba Lake, Man. (J. Clarke.) Produced here from the egg, hatching about June first. Left about the end of July, going south west. No winged swarms observed to arrive. No grain sown. Potatoes and hay meadows considerably damaged. No eggs known to have been deposited.

Pigeon Lake, Man. (J. M. Haure.) Produced here from the egg, hatching from 15th of May till 15th of July. Commenced flying July 10th, and continued leaving till the middle of August, going south and south-east. Foreign swarms seen at various time—first on July 1st—passing overhead. These came from south and south-west, and went north-westward as a rule. No grain raised in Parish of François Xavier. No eggs known to have been deposited.

St. François Xavier West, Man. (F. Dauphenais.) Produced here from the egg, hatching early in May. Began to leave about the 10th of July, going south. Locusts arrived on the wing from the south-west about the 25th of July. Said to have kept coming and going, occasionally alighting. Left early in August, going south. Three-fourths of crop in the parish destroyed. No eggs deposited.

Headingly, Man. (J. Taylor.) Produced here from the egg, hatching about the end of May. Left from the middle to the end of August, going southward. Winged swarms arrived from various directions, but more especially from the south. Myriads lit about the 20th of July. Eventually flew southward with those hatched here. Three-quarters of crop, or probably about 10,000 bushels destroyed. No eggs deposited.

St. Charles, Man. (A. Murray, M.P.P.) Produced here from the egg, hatching from about the 10th of May to July 1st in successive swarms. On arriving at maturity went south-east, ward. About July 10th winged swarms arrived from the west and left in the same direction as those produced here, the latter in many cases rising and mingling with them. Entire grain crop destroyed, and only a few inferior potatoes harvested. No eggs deposited.

Rockwood, Man. (J. Robinson.) Produced here from the egg, hatching about the middle of June. Left about the last of August, going south-east. Swarms passed overhead about July first, coming from the south. All crops destroyed.

West Lynne, Man. (H. G. Lewis.) Produced here from the egg, hatching about the 20th of May, and leaving southward toward the end of July. Swarms are said to have arrived from the south, and to have left again going southward, about the date last given. Two-thirds of crop destroyed. No eggs deposited.

Selkirk, Man. (A. A. Ross.) Produced here from the egg, hatching from the 10th of May, till the 10th of July. Left in latter part of July, going south-eastward. A few swarms arrived on the wing and alighted on the 29th of July. These left with those produced in the district. Scarcely any grain sown. Potatoes put in late, were harvested without much damage. No egg deposited.

Winnipeg, Man. (Wm. Hespeler, F. Cornish, C. Inkster.) Produced here from the egg, hatching during latter part of May and first of June. Began to leave in second week in July, going as a rule south and south-east. Winged swarms from the north-west observed about the middle of July; generally passing overhead without alighting. Flew in same direction with those hatched here. Little crop put in, and more than three-fourths of that destroyed. No eggs deposited.

St. Boniface, Man. (Hon. M. A. Girard) Produced here from the egg, beginning to appear in May. Left during August, going eastward. From the 15th of July to the 15th of August other swarms arrived from the south and west, and for the most part passed overhead going north and east. Few eggs deposited. Twenty-four twenty-fifths of crop destroyed.

St. Norbert, Man. (J. Lemay.) Produced here from the egg, hatching about the middle of May. Began leaving about the 22nd July, going west. Nine-tenths of crop, amounting to about 25,000 bushels, destroyed. No eggs deposited.

Parish of St. Vital, Man. (S. Hamilton.) Produced here from the egg, beginning to hatch out early in May. Left about the end of August, going south-south-east. Some swarms arrived on the wing about the 15th and 20th of June from the north-westward, and left at about the same time, and in the same direction, as those produced here. All crops, save a few fields of pease, destroyed. Eggs deposited during the summer but young insects hatched and destroyed by frost.

St. Vital, Man. (A. Gaudry) Locusts hatched here about about the first of June, and on obtaining their wings left, going north-east. Foreign swarms not mentioned.

Middle Church, Man. (J. Clouston.) Produced here from the egg, hatching from about May 15th till June 15th. Left in August, going south; all gone before August 15th. No foreign swarms mentioned. All crops sown were lost. No eggs deposited.

Little Britain, Man. (Hon. D. Gunn) Produced here from the egg, hatching from about May 7th till the middle of June, and a few even later. Some began to fly off about July 20th, others between that date and the 20th of August, and a few seen as late as the 8th or 10th of September. At first a few flew to the north, but returned, and all at length flew to the east and south-east. Very little grain sown, and all destroyed. No eggs deposited. Mr. Gunn writes that some eggs were deposited in the vicinity of Lake Winnipeg in the autumn of 1875.

Lower Fort Garry, Man. (Wm. Flett) Produced here from the egg, hatching during the greater part of the month of May. Most left during the latter part of July, though some still to be found till about middle of August; generally went south-east. No foreign swarms. No eggs deposited.

Springfield, Man. (F. Dick) Produced here from the egg, hatching May 15th to June 1st. Left during latter part of July and August, going south-east. About July 15th swarms appeared from west and north-west, and continued to pass over, alighting sometimes for the night, till about August 6th. In Electoral District of Springfield only about 700 acres sown. Crop saved on 25 acres only and even this much damaged.

Eagles Nest, Man. (J. Monkman.) Produced here from the egg, hatching from May 20th to July 15th. Left July 15th, going east-south-east. Winged swarms observed to pass overhead, some alighting. First noticed July 1st, and continued until August. Came from west-north-west, and went east-south-east. No eggs deposited.

Cook's Creek, Man. (G. Miller.) Produced here from the egg, hatching about the first of May. Departed about the first of August, going south-east. Swarms also passed overhead about August first, coming from the north-west, and going in the direction aforesaid. Total destruction of crops.

Crookston, Minn. (E. M. Walsh.) A few locusts produced here from the egg, hatching from May 15th to June 10th. Left July 15th, going south and south-east. These did little damage. Swarms appeared on the wing from the north, and passed south-eastward, about July 20th. Crops not injured. No eggs deposited.

North-West Angle, Lake of the Woods. (M. M. Thompson.) No locusts hatched here. Swarms arrived on the wing about August first from the north-west, and left again about the 20th of August, going south-east. Only crops put in potatoes, which were nearly all destroyed. No eggs or young insects observed in the autumn.

Mr. Thompson writes that these notes will apply equally to *Broken Head, White Mouth,* and *Birch River.* These are stations in the wooded district east of the Red River Prairie, and on the road between Winnipeg and Lake of the Woods.

NOTES ON SOME GEOLOGICAL FEATURES OF THE NORTH EASTERN COAST OF LABRADOR.

By Henry Youle Hind, M.A.

1. Area described.—2. Rock Cleavage.—3. Pan Ice.—4. Extent of Pan Ice Work. 5. Glacial Striæ and Glacial Clays.—6. Icebergs.—7. Formation of Boulder Clays.—8. The Marine Climate of the Labrador Coast.—9. The Crystalline Limestones of the Laurentian Series.

1. Area Described.

The part of the North-eastern Coast of Labrador to which reference is made in these notes, extends from Sandwich Bay (Lat. 53° 45′ N.) to Ukkasiksalik or Freestone Point (Lat. 55° 55′ N.), a distance measured coastwise of about 230 miles. Freestone Point is 350 miles north-west of Belle Isle, and it takes its misleading name from the existence there of considerable pockets of the 'Ukkasik' or Potstone of the Esquimo.*

I am indebted to Francis Ellershausen, Esq., one of the proprietors of the already celebrated Betts Cove Copper Mine in Newfoundland, for the opportunities enjoyed last summer of visiting this little known part of British America, and of making the observations which form the subject of these brief notes.

The main body of Hamilton Inlet, and its South-westerly extension Lake Melville, penetrating 130 geographical miles into the interior, and receiving the waters of numerous large rivers, is well known in its general geographical features, but nothing has been published of its two great arms "The Double Mere" and "the Backway." The Double Mere is reported to be fifty miles deep, and the Backway is stated to extend near to Tub Harbour on the main coast. I could not see the extremities of either of these deep arms from the deck of a schooner on a clear day when passing their entrances. The numerous and profound Fiords which indent the coast line beyond Cape Aillik (lat. 55° 11′, long. 59° 11′) are altogether undescribed. The Admiralty

* Ukkasik, the kettle; ukkasiksak, the stuff for the kettle; ukkasiksa-lik, supplied with that stuff for the kettle;—the k at the end of 'sak' being dropped for euphony.—The Rev. Brother Elsner, Missionary at Hopedale.

chart published on the 10th July, 1876, from partial surveys by Staff Commander Maxwell, R. N., is a great step in advance in the correct delineation of the north-eastern coast of Labrador, but merely the entrances to the most important Fiords are shown, with a note indicating there supposed depth inland.

Islands begin to be numerous a few miles to the east of Sandwich Bay. They form a belt or zone protecting the mainland all the way to Cape Chudleigh, at the entrance of Hudson Straits, about seven hundred nautical miles from Belle Isle. By means of the constant action of "Pan Ice" hereafter described, all exposed portions of these Islands have been polished with such uniformity that a perfect picture of their structure is exposed to view.

The farther to the north we advance, the more remarkable are the planed surfaces. The minutest detail of stratification, of undulation, dislocation, fold or vein is as clearly visible over many hundred acres on low islands, as if the wide expanse had been laboriously and carefully polished by artificial means.

The low lying surfaces are still annually submitted to a renewal of the polishing process by the never failing pan ice, and it is thus that in some favourable localities square miles of rock show the "grain" as clearly as a well kept mahogany table exhibits the grain of the wood.

Before alluding to the general structure of the area visited last summer, which by the way, is characterized by extraordinary regularity and symmetry, I shall briefly notice the means by which so much of the detail and arrangement of the strata is exposed to view. The abrading and polishing agent is, as already stated, pan ice, but this is assisted in a very marked degree by rock cleavage.

2.—Rock Cleavage.

The cleavage of the old Laurentian Rocks here is generally at right angles to the bedding, or nearly so, and whenever the strata incline towards the prevailing direction of the ice drift or thrust on the exposed coast, the wearing away is rapidly accomplished by the removal every year of large blocks, the resulting surface being left in a series of steps or terraces.

Some illustrations of these steps are seen near Hopedale, and especially in Tooktoosner Bay south of Hopedale. The steps are now polished and the edges neatly rounded ; they may rise

120 feet above the present sea margin, each step being about four or more feet in altitude, such being the average thickness of the beds of gneiss. In Lake Melville, Hamilton Inlet, the process of breaking down the rock into steps, assisted by cleavage, is well seen on St. Patricks or Haines' Island, opposite to the mouth of English River. Here and at various other parts where a similar terrace or step disposition on the slope of the hills occurred, I was reminded of the "Gneiss Terraces" at the Level Portage, on Cold Water River, an affluent on the Moisie, which I described in 1862.*

The Gneiss Terraces there are about 800 feet above the sea level, and their aspect is similar to the steps in Tooktoosner Bay, leading to but one conclusion, that surface outline, where ice influence has prevailed, is largely due to the action of coast ice upon strata in which cleavage planes and joints readily assist denudation in the manner described.

The process of detaching and carrying away the blocks separated by cleavage planes and joints may go on until the strata exposed to this action are removed, or a change in the direction of the impinging masses of ice takes place, or until beds are reached in which cleavage planes and joints no longer facilitate the operation, when the rasping down, and finally, the polishing process begins, and a *roche moutonnée* results. These operations occur in the spring only, when the coast fringe of ice, which extends far out to sea, is broken up, and "pans" of ice are formed by the disruption.

3.—Pan Ice.

"Pan" ice is derived from Bay ice, floes and coast ice, varying from five to ten or twelve feet in thickness, all of which are broken up during spring storms. When the disruption of the ice sheet which seals the Fiords, the Island zone and the sea itself for many miles outside, continuously, is effected in June, the resulting "pans" as the fishermen term them, vary in size from a few square yards to many acres in extent. The uniform and unbroken mass of ice in the winter months, has no lateral motion, it rises and falls with the tide, but is unaffected by winds until the warmth of spring softens its hold on the

* Vide, Explorations in the Interior of the Labrador Peninsula—Longmans, London, 1863.

Islands to which it is keyed. When the pans are pressed on the coast by winds, they accommodate themselves to all the sinuosities of the shore line, and being pushed by the unfailing arctic current, which brings down a constant supply of floe ice, the pans rise over all the low lying parts of the Islands grinding and polishing exposed shores, and rasping those that are steep-to. The pans are shoved over the flat surfaces of the Islands and remove with irresistible force every obstacle which opposes their thrust, for the attacks are constantly renewed by the ceaseless ice stream from the north-west, and this goes on uninterruptedly for a month or more. Sometimes a change in the wind brings the endless sheet back again, and it is the middle of July before some of the Fiords are clear of ice. Hence boulders, shingle and beaches are rarely seen except in sheltered nooks and coves, and the masses *pushed* or torn from those surfaces where cleavage offers a chance of disruption, are urged into the sea and rounded into boulder form by the rasping and polishing pans.

Here too goes on the process, subsequently referred to, of manufacturing Boulder Clay, for the deep hollows and ravines, at present under the sea—the records of former glacial work—are being filled with clay, sand, unworn and worn rock fragments, producing a counterpart of some varieties of Boulder Clay.

But this is not all of the work of pan ice. The bottom of the sea, to the depth of 12 or 15 feet, and at all less depths, is smoothed and planed by the drifting masses when they pile one on the other, and at depths less than eight feet when the pans are driven before the wind or carried by the currents. In sailing from Aillik to Nain or to Cape Mugford, the fishermen send a man aloft to look out for "White Rocks." These are prominences or swells in the general level of the sea bottom among the Islands, from which every particle of sea weed has been removed by pan ice.

The "White Rocks" are clearly visible in smooth water, and in rough weather "they break." Hence it is that pan ice is exerting an abrading action over a vast coastal and submarine area throughout the shallow seas which fringe the Labrador. It is pushing too the blocks of strata removed from the coast, backwards and forwards on the sea bottom, sometimes landing and leaving them on islands, and again in the following season push-

ing them into the sea, but each year causing them to assume more and more the boulder form. While clearing the ridges and planes on the sea floor it is piling or rather pushing the worn blocks into depressions and accumulating the debris in the shallow ocean valleys. In a word, it is doing before our eyes over a coast line many hundred miles in length, what has been done in earlier times over a vast area of the North American Continent, according as fresh surfaces by a rise or subsidence of the land were brought under the powerful and searching influence of pan ice aided by an Arctic current.

The influence of the Arctic Current shows itself throughout the Island zone, in a remarkable manner, giving rise with each change of the tide to ever varying eddies. Its speed through the Islands is greater than beyond their limits, where the fishermen estimate it at a knot to a knot and half an hour. Sailing among the Islands the fishermen going north-west generally count sixty miles sailing distance as equivalent to moving eighty miles through the water, on account of the current, which resembles that of a great river.

4.—Extent of Pan Ice Work.

The amount of work done by pan ice during the gradual rise of the land, is well shown by the polished surfaces and sides of hills many hundred feet above the sea level. I had no opportunity of testing by actual touch its abrading effects to a greater altitude than six hundred feet above the ocean, but I saw after rain the smooth glistening surfaces in great profusion over the steep sides of mountains at a much greater elevation. Erratics, and local rounded fragments of rock are not numerous until a height exceeding one thousand feet is attained, and even then, except perhaps in hollows, which I had no opportunity of examining, boulders and perched rocks are very much less numerous that at greater elevations in the far interior, where I saw them in countless multitudes in 1861. Below the level of perhaps twelve hundred feet they have been made and removed by pan and coast ice, and the country in this respect presents a counter part to the Upper Moisie Valley, where the "remarkable absence of erratics on the Moisie until an altitude of about 1000 feet is attained, may be explained by the supposition that they may have been carried away by icebergs and *coast ice*

during a period of submergence to the extent of about 1000 feet."*

The manner in which Ice blocks and pan ice acts as a powerful transporting and denuding agent in tidal estuaries and deep Bays is described with some detail in a paper on the "Ice Phenomena of the Bay of Fundy. †

Since my return from the Labrador I have had an opportunity of reading the excellent articles on "Ice and Ice Work in Newfoundland," by Mr. John Milne, F. G. S., published in the July, August, and September number of the Geological Magazine for 1876. At the time when the July number of this Magazine was passing through the press, I had an opportunity of seeing some hundreds of square miles of Floe Ice driven on the Coast of Notre Dame Bay, Newfoundland, by a north-easterly wind. Had this occurred in February or March when the temperature falls during the night many degrees below the freezing point, the "glueing" of large quantities of coast debris to the ice fringe, and its subsequent conveyance out to sea on a change of wind, in the manner so graphically described by Mr. Milne, would have occurred simultaneously over a coast line not less than fifty miles in length.

5.—Glacial Striæ and Glacial Clays.

Although the profound Fiords are doubtless the result of local glaciers, some of which are said still to exist beyond Hebron, yet a very careful search failed to reveal, except in one instance only, any glacial striæ, or indeed striæ of any description. In Tooktoosner Bay close to Hopedale, I saw in a secluded and protected hollow, well marked, and deeply cut, grooves. They occupied a shallow cup-shaped basin, but all surrounding surfaces were smoothly polished, pan ice having removed every trace of groove or striæ. Glacial clays of considerable thickness are not uncommon in sheltered valleys opening into the Fiords. They were seen on English River, Lake Melville, also of precisely the same description in Tooktoosner Bay. Twenty feet in thickness of the clay was visible over the water of English River, but

* Vide—A Paper "On supposed Glacial Drift in the Labrador Peninsula, &c." by the author. Quarterly Journal of the Geological Society, London, 1864, page 124.

† "Ice Phenomena in the Bay of Fundy," by the author—published in the Canadian Monthly, September, 1875.

it was capped by an enormous deposit of stratified sandy drift, at least 70 feet in thickness. A portion of the pale bluish glacial clay was washed and found to contain numerous unworn and angular fragments of rock and a considerable quantity of black magnetic oxide of iron. The beds of stratified sandy drift were seen in many places, as for instance, at the narrows above Rigolette, at the mouth of English River, in Kebouka Bay or Fiord, &c. The highest terraces observed were fully 120 feet above the ocean. Remnants of gravelly beaches were found at levels below six hundred feet, occupying well sheltered nooks and coves. They were often seen beyond Aillik to exhibit a well defined terrace arrangement. One of the best examples of this succession of gravelly terraces was observed near Cape Aillik. On American Island, close to Cape Hurricane and 20 miles north of Hopedale, a beach was seen at an altitude of six hundred feet above the sea, and its aspect was so modern, that it looked as if the waves had left it but yesterday.

It is noteworthy that in this instance the situation was exposed, and it is difficult to imagine that this remnant of a beach could have been subjected to the action of pan ice without being not merely disarranged, but swept altogether away. Upon entering the deep Fiords, and proceeding beyond what may be termed the narrows, where pan ice has but little power, a lake shore aspect is at once visible. Sandy beaches, lines of boulders, remnants of terraces, and wooded slopes all tell of a period of repose, but scrape away the peat from rocky surfaces many feet above the present sea level and if the rock should be resisting gneiss, the polished surface reveals the universe action of pan ice. Showers of rain show glistening surfaces far up the steep sides of mountains where no moss or lichen has yet found a lodgment, though several feet in thickness of peat may occupy the terrace flats; and at the base of the slopes where a soil can accumulate there is a forest growth.

The aspect of portions of the terraces of stratified sand, gravel, shingle, and fine clay, now washed by salt water far up the deep Fiords, and sometimes resting on Glacial Blue Clay, suggest a different origin to that which gave rise to the unquestionably marine beds seen on the Southern Labrador Coast holding marine fossils. (Vide Packard.)*

* Canadian Geologist.

While we have evidence before our eyes of the subsidence of the entire country and its subsequent elevation, we can not reject the probable supposition that previous to the subsidence the whole country was far more upraised than it now is. A general upward movement of 1500 feet would cut off the Arctic Current, or reduce it to the dimensions of a river, both from Davis and Hudson Straits, these being the only existing channels between the Arctic and Atlantic on the American side.* This would produce a change in climate of a very marked character, and give rise probably to wide spreading areas of fresh water where now sea and land appear.

The Arctic or Labrador Current is the one great cause of the extreme climate of the Labrador Coast. It keeps the bays and Fiords on the whole North Eastern Coast closed by ice from December to June. It permits the formation of anchor or ground ice to an extraordinary extent at the commencement of winter. The sea bottom freezes in sixty and seventy feet of water, and fresh water flowing under the first ice formed, into the sea cooled by the Arctic Current, is instantly converted into spongy masses, and assists in choking the fiords. Seals taken in seal nets in November and early in December in 60 feet of water, are often found "frozen solid"; and fishermen several times put it to me as a problem passing solution, why frozen seals taken from a seal net sunk to the bottom in fifteen and even eighteen fathoms water, should thaw when kept for a few hours at the surface. The discoveries by Desprets have explained all this, but at the same time they have enlarged our views respecting the variety of ways in which ice can act as a geological agent when an arctic current is present to assist in its formation.

The differences between the condition of the Labrador and the Norwegian Fiords is remarkable; while the first named are closed by ice during at least six months of the year as a consequence of the Arctic Current flowing past them, the last named, according to Admiral Irminger, are kept open by a constant flow of warm water from the south-west, and the effect of this warm current is felt as far as Cape North. The cessation of the Labrador Arctic and Davis Strait Current by a general rise of the land between Greenland and Labrador would greatly

* Vide any good *recent* Map of the Arctic regions.

change oceanic circulation according to the views of Dr. Carpenter. That such a continental elevation has taken place during the last geological epoch there are strong reasons to believe, and I hope during the coming summer to obtain additional evidences from drift deposits, to support this view, as well as to establish the former existence here of wide spreading fresh-water lacustrine deposits.

6.—Ice-Bergs.

The climate of the Labrador Coast derives much of its low temperatures from sources extremely remote. The unceasing ice stream, in the form of ice-bergs, which sweeps past it, receives no inconsiderable portion of its material from the seas of Eastern Greenland, Iceland and even perhaps Spitzbergen, and if icebergs possessed the opportunities for transporting rock masses and other materials to the extent with which they have been credited, we might expect to see the shores of north-eastern Labrador strewed with blocks derived from East Greenland. as well as from West Greenland. But out of the thousands of ice-bergs I saw quite near at hand last summer, in one or two instances only did I detect any foreign material. The ice in *general* was stainless, though often well stratified on the exposed sides. Whatever might have been hidden in the holes and valleys on the upper portion of the bergs, was of course not visible from the deck of a passing vessel. I have attempted to show elsewhere* that infusorial life accompanies the ice-bergs to a remarkable extent, and that the great ice-stream from East Greenland seas, sweeping past Cape Farewell, thence northerly, north-westerly, westerly and southerly until it comes on the Labrador, is a vast distributing agent of fish ova and indirectly of fish food, but as to its geological work on the scale which has been assigned to it, there does not appear to be any evidence on the north eastern Labrador. It is no doubt adding a small amount of debris to the banks on which the bergs strand, and is deepening the water on the coasts which are steep-to, by the incessant rolling and grinding of the bergs with the swell of the sea.

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* 'Notes on the Northern Labrador Fishing Grounds'—Nov. 1876; also 'Notes on Anchor Ice,' Dec. 1876 and Jan. 1877.

Off the North-eastern Coast of Labrador, and generally on banks ten or fifteen miles from the outermost Islands, there is a loose fringe of stranded bergs for hundreds of miles. They are continually "foundering," that is breaking up during the summer. Sometimes they are grouped together, sometimes a mile a part, but still forming a continuous string as far as I saw them, for a hundred-and-fifty miles, north-west of Cape Harrison. Some years the fishermen say they are much more numerous than during other seasons, but I rarely counted fewer than thirty within view at the time from the deck of the Schooner, and often a much larger number. Outside of the stranded bergs the giant "Ice Islands" as they are locally termed, drift with the Arctic Current south-easterly. Very few bergs were seen among the Islands, or between the stranded bergs and the Islands. The shoals or banks "pick them up." In fact it is only small disrupted masses that one meets with; within the Islands Zone the water in general being too shallow to float a berg of considerable size.

7.—Formation of Boulder Clay.

During a period of subsidence the blocks of strata, boulders, mud, and sand, pushed to and fro on the shallow-sea-bottom by pan ice, ultimately accumulate in hollows and ravines below its action, and when the debris is pushed into profound submarine valleys such as exist on the Labrador Coast, (being probably due to former glacial action,) the mass will resemble Boulder Clays, and in a sinking marine area it will accumulate to a great thickness; in a rising area it would be liable to be remodelled by the action of the waves except in the case of very deep valleys. There are not many known narrow and profound submarine valleys on the north-eastern coast of Labrador, but those which are known offer precisely the conditions required for the accumulation of Boulder Clays or drift by the action of Pan Ice.

The seaward extension of Uksuktak Fiord, which lies a little to the south of Hopedale, affords an apt illustration. Commander Maxwell's soundings show a profound submarine ravine between clusters of Islands for upwards of eight miles, in which the depth reaches, 124, 126, 123, 106 and 130 fathoms. Between the Islands of Niatak and Paul, near Nain, the lead shows 71 fathoms. It is evident that the material torn from the sur-

rounding islands by Pan Ice and pushed along the bottom of the sea into these profound submarine valleys during a period of general submergence will be protected from the action of the waves, and the loose blocks and boulders will have a forced arrangement in the mud, as if they had been pushed over a bank, and thus produce the irregular disposition so frequently seen in boulder clay deposits. In such narrow and profound valleys as those instanced, the accumulation of Boulder Drift probably goes on at the present time, and may continue during a period of elevation, until large portions of the drift are raised above the sea level and beyond the influence of the waves, which will attack only its sea-front. But the agent which gives rise to this heterogeneous mass is Pan Ice, and the formation of Boulder Clay is very probably a part of its work over a vast area on the Labrador at the present day, throughout the Labyrinth of Islands which fringe that coast to a depth of twenty miles seawards. If one examines the local deposits of Boulder Clay in various parts of Nova Scotia, with ice-worn gneissic rocks close at hand, or underlying the clays, the conclusion that pan ice has been instrumental in accumulating many of those deposits is irresistable. The pushing of blocks of strata by ice is graphically described by Dr. Dawson on page 65 of his Acadian Geology, 2nd Ed.

8.—The Marine Climate of the Labrador Coast.

It has been shown by Dr. Petermann and others that the difference between the coastal climate of Greenland and the Labrador is very great. The south-western Coast of Greenland is much milder than that of the Labrador in the same parallels.* A surface sheet of warm water, flowing from South to North, is determined on to the coast of Western Greenland by the rotation of the earth. A cold Arctic current ladened with ice from Davis and Hudson Straits flows from North to South and is determined on to the Labrador Coast by the rotation of the Earth. Hence the sea on the Labrador Coast is cooled sometimes in November and early in December to 29, and even 28 degrees, and the "Lolly" of the sealers, or Ice Speculæ, or Anchor Ice, forms rapidly during the first cold snap in November, along the entire

* Vide a paper entitled "Further Enquiries on Oceanic Circulation" by Dr. W. B. Carpenter, F.R.S., Proceedings of the Royal Geological Society, August, 1874.

coast line; and before Christmas, all the coastal waters within the zone of Islands are frozen in one solid sheet, so that no "Ice foot" is formed on the Labrador like the 'Ice foot" on the Greenland shores. In brief, it may be said that the stupendous work of Ice on the Labrador, apart from Glacial Sculpturing, appears to be almost altogether due to the periodical action of pan ice, deriving its power and constant opportunities, from the Arctic Current which presses continually on the Labrador Coast.

THE LAURENTIAN SERIES.

9.—Crystalline Limestones.

The occurrence of Upper Laurentian Rocks on the Labrador Coast has long been known, and their approximate limits are laid down on a map which was published some years since in Petermann's Mittheilungen, the data being chiefly derived from the observations of the Moravian Missionaries. The area occupied by the Upper Laurentian on this extensive coast is represented to be very considerable, and that it extends far back into the interior is probable from the fact that in 1861 I found Labradorite rocks on the Upper Moisie River, the locality being represented on Sir W. E. Logan's Geological Map published in 1864.*

During the last summer (1876) I met with a thin band of Crystalline Limestone about 35 feet in thickness in Hamilton Inlet, at the place called Mullen's Cove.

Mullen's Cove is situated eleven miles due East from Rigou lette, the Hudson Bay Company's Post, and its position is shown on the Admiralty Chart of Labrador by Commander Maxwell, R. N., published 10th July, 1876.

With a view to illustrate the regularity and variety of the strata in the vicinity of the Crystalline Limestones, the following section was roughly measured by my friend Mr. Colchester and myself in August last, across the strata.

The Series was well exposed on the Coast of Hamilton Inlet, and offered unusual facilities for examination in detail. It includes at the summit a band of limestone before noticed, also small bands of limestone from 4 feet to one inch in thickness in No. XI.

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* Vide page XII. Geology of Canada, 1863.

Section in Hamilton Inlet.

Section No. I,—Ascending Order.

Dip S. 52 E. (True) angle 30°. Cleavage planes at right angles to dip. East side of Mullen's Cove.

Bed No.		*Thickness Feet.*
18	Grey weathering, finely banded, quartzose gneiss, with lenticular layers of micaceous schist. At the base the band becomes more micaceous until it passes into a compact dark grey mica schist, some of the layers garnetiferous	200
17	Finely banded gartnetiferous gneiss	50
16	Fine grained gneiss,—with coarse granitic Dyke cutting the strata at a low angle,—interstratified with garnetiferous, micaceous bands	37
15	Compact micaceous schist with small garnets	10
14	Finely banded gneiss, some layers garnetiferous	60
13	Garnetiferous gneiss	26
12	Very coarse quartzose gneiss with numerous patches and crystals of quartz	18
11	Banded gneiss in very thin layers with a bed of *calcareous conglomerate*, 13 inches thick; thin layers of crystalline limestone, from four feet to one inch in thickness, and thin layers of coarse gneiss, mica schist, and felspathic schist	120
10	Coarse banded gneiss	60
9	Coarse gneiss with bands of fine micaceous schist	6
8	Red Felspathic gneiss	6
7	Banded gneiss	25
6	Coarse quartzose gneiss	25
5	Dark colored micaceous gneiss	6
4	Band of garnetiferous gneiss	20
3	Fine banded micaceous gneiss	30
2	Coarse banded gneiss with granitic veins	18
1	Coarse gneiss	8
	Total thickness	727

Section No. II.

West side of Mullen's Cove, and between Mullen's Cove and Collingham Bight.

a. Coarse felspathic gneiss, with small garnets distributed through the mass.....
b. *Crystalline Limestone*..... 35
c. Coarse grey garnetiferous gneiss with large garnets distributed through the mass.....
d. Ferruginous gneiss containing Iron pyrites in thin bands.

Both Series are regular, and garnets appear pretty generally distributed. In some of the beds crystals and grains of magnetite are visible. The Crystalline Limestone is white and saccharoidal in parts. It is seamed near its junction with the overlying gneiss, with thin lenticular bands of micaceous schist, and a thin band of felspathic gneiss. It contains near the gneiss crystals of magnetite and specks of carbonate of copper. Its colour is white to a pale yellowish tinge. Some bands are very pure and resemble coarse loaf sugar. When treated with hydrochloric acid the residue contains milk-white opaque grains and grains of light semi-transparent grass-green mineral, which in some parts appears to be disseminated through the mass.

Near the narrows of Kebouka Bay, 75 miles north-west of Mullen's Cove, two kinds of Crystalline limestone are found in the shingle, one white and compact, the other grey and coarse in structure, but the rock was not seen in place.

The structure of the strata as seen on the coast leads to the impression that the limestones are brought to the surface by undulations. The Moravian Missionary at Hopedale, showed me a slate of crystalline limestones which he had picked up near to that station.

NOTE ON SOME OF THE MORE RECENT CHANGES IN LEVEL OF THE COAST OF BRITISH COLUMBIA AND ADJACENT REGIONS.

By George M. Dawson, Assoc. R.S.M., F.G.S.

The elevation of the Cascade or Coast Range of British Columbia, and the parallel range of Vancouver Island, must have taken place to a great extent, though probably not entirely, in post cretaceous times. On the upturned and denuded edges of Cretaceous rocks, in the interior of British Columbia, rest nearly horizontal beds, which appear to be of Miocene age, and which pass upward into the great sheets of volcanic material, with which the whole interior plateau must at one time have been covered. The sedimentary Miocene beds seem to have been formed in fresh-water lakes, produced perhaps by interruption of the drainage by mountain elevation, which there is evidence to show, may have continued to some small extent even in post-miocene times. The country cannot have been so low at this period as to admit the sea to the interior plateau, but appears to have been depressed to a small extent, as marine tertiary beds, probably of this age, are found along the coast above the present sea-line. No Pliocene deposits have yet been recognised, and it was probably during this period, with the land standing at least 900 feet higher than at present, that the deep river valleys or canons now forming the remarkable system of fjords by which the coast is dissected, were cut out. These fjords are very generally in their sheltered upper reaches over 100 fathoms in depth, often over 150 fathoms, and probably in many cases over 200; though in most of them the actual depth has only been ascertained in a few places. When they open on the broader waterways, where the strong tides of the Pacific coast run with greater power, they are found to be silted up, and blocked with bars and banks; the water being generally shoalest where the water stretches are most extensive. This is especially noticeable on the west coast of Vancouver Island. The ice which can be shown to have filled these fjords during the glacial period, must have deepened them and altered their forms to some extent, but probably in a degree quite inconsiderable when compared with their pre-glacial excavation.

During the glacial period the country was submerged, but into the history of this epoch, and evidence of the very great extent of this submergence, I do not propose here to enter. In my Report on the Geology and Resources of the 49th Parallel, I have given the grounds which lead me to believe in a submergence at this time of at least 4,400 feet, on the eastern slopes of the Rocky Mountains. In the central portions of British Columbia, ice-bearing water must have stood at a level of 5,270 feet. I do not wish to insist that this must necessarily have been the sea, though that appears best to account for the facts.

Mr. George Gibbs states,* that the passages and inlets of Puget Sound, in the northern part of Washington Territory, are excavated in many places in drift deposits, which appear not only to form their present banks, but to underlie their beds. If this be correct, there is here pretty good evidence of a post-glacial elevation of the land to a height somewhat greater than the present; for the long river-like inlets, referred to, bear all the appearance of having been *formed* by river erosion and afterwards filled and widened only by the action of the sea and tidal currents.

No elevation or depression of the coast of the southern part of Vancouver Island is known to have taken place very recently, but the aspect of the shore is that of one gradually subsiding, and I had arrived at this conclusion from its examination before meeting with the statements of others, shortly to be mentioned. Near Victoria the low rocky substructure of the country, is partly enveloped in a somewhat irregular terrace, of which the average height may be about 40 feet. It is composed of clays, more or less arenaceous, holding boulders, and in some places also marine shells indicating pretty deep water. Cliffs of this clay are being rapidly wasted, along some parts of the shore, where the water may be seen during the higher winter tides actually removing this material from the polished and glaciated rock surfaces, wave by wave. The rocks about high water nearly all preserve very perfectly their glacial markings, which lower down are not so distinct; but in many places even where they receive the full force of the sea at every tide, they are much better preserved than would be the case if they had been for an indefinite number of years exposed to its action. In shallow bays, where the sloping pebbly beach is bordered land-

* Am. Journ. Geog. Soc. 1874, p. 308.

ward by a low perpendicular bank of the clays, I have seen the water during the high tides of winter actually above the stony beach, and beating against the clay, with which it was rendered turbid for some distance from the shore. In certain localities the old Indian shell heaps or kitchen-middens, which are abundant on this coast, are exposed in section by the sea in similar low banks, and the lower layers of some of these have been observed to be nearly a foot, in some places, below the high tide mark; showing I think that subsidence to a small extent has taken place since they were formed. The Indians would scarcely choose for camping a place liable to overflow, and if the shells were merely thrown there, they would have been scattered from time to time by the high tides, and would not have accumulated in heaps six to eight feet thick and very wide.

The land was probably at a somewhat lower level, when first inhabited by the Indians, for the upper layers of the pale clayey drift above referred to, merge in some places quite gradually into a darker coloured and more earthy material, from six inches to two feet in thickness, which forms the soil of the cultivable tracts. This follows the slope of the surface and was probably deposited by the retreating waters, when for a time each level was an oozy sea margin, like that found at the heads of some of the present sheltered bays, in process of transition to land, and including in its mass much decomposed vegetable matter. In the very lowest layers of this darker material, I have noticed in one or two places, at heights of five to ten feet above the present beach line, burnt stones like those used by the Indians in cooking, and other signs of their presence.

There is no evidence to show that any movement greater in amount than a few feet, has taken place for a long time. The growth of very large trees near the present high water mark in the sheltered inlets, would seem to negative any great elevation. It would also seem probable that the movement of depression indicated in the extracts from Vancouver and Cooper, may have taken place rapidly, perhaps in connection with some of the small earthquake shocks by which this coast is visited from time to time. At the heads of all the inlets or fjords of the coast, a stretch of low, flat, and often marshy ground, shoaling very gradually seaward, and then in quarter or half a mile beyond the shore plunging steeply down into deep water, surrounds the mouths of the entering rivers. The position of these flats with

regard to the sea level is very much what we might expect from the action of the rivers and tides still in progress, though in some places they are probably a little higher than the present circumstances will explain. Had the coast permanently changed its elevation by as much as fifty feet in either direction, during many centuries, the aspect of affairs would no doubt be quite different.

Vancouver gives in the course of his relation, some singularly interesting statements bearing on the sinking of the coast. Of Port Chalmers, in Prince William's Sound (lat. 60° 16′) under date June, 1794, he writes* :—

" The shores are in general low, and as has already been observed, very swampy in many places, on which the sea appears to be making more rapid encroachments than I ever before saw or heard of. Many trees had been cut down since these regions were first visited by Europeans ; this was evident from the visible effects of the axe and saw, which we concluded had been produced whilst Messrs. Portlock and Dixon were here, seven years before our arrival, as the stumps of the trees were still remaining on the earth where they had originally grown, but were now many feet below the high water mark even of neap tides. A narrow low projecting point of land behind which we rode, had not long since afforded support to some of the largest pine trees in the neighbourhood, but it was now overflowed by every tide, and excepting two of the trees which still put forth a few leaves, the whole were reduced to naked, dead white stumps, by the encroachment of the sea water to the roots ; and some stumps of trees, with their roots still fast in the ground, were also found in no very advanced stage of decay nearly as low down as the low water of spring tides."

The place here spoken of by Vancouver, has it seems lately been called *Sinking Point* by the U. S. Coast Survey. It is mentioned under this name by Mr. Davidson in the Alaska Coast Pilot (1869) who however gives no description of its present appearance. Mr. Davidson suggests that the trees observed by Vancouver may have been felled by the Russians before Portlock and Dixon's visit, but as these commanders stayed here ten days, careening and overhauling their vessels,

* A Voyage of Discovery to the North Pacific Ocean and Round the World. London 1801. Vol. V., p. 335.

and yet make no mention of signs of previous visitors in their narrative,* it is probable that Vancouver was correct in his supposition. Mr. Dall, in the Coast Pilot (p. 193) shows pretty conclusively that the peninsular part of Alaska, west of the 150th meridian, is being, or has lately been elevated. Winrows of drift wood in various stages of decay are found above the highest levels ever now attained by the sea, and in the crevices of rocks, fifteen feet above high water, portions of the shelly covering of a species of barnacle are found *in situ*. He also refers to Sinking Point, but inclines to the belief that the subsidence there shown is merely local, which, in view of the other facts here cited it can scarcely be.

In detailing the observations of his sailing master, Mr. Whidbey, on another part of the coast, near Admiralty Island† (near lat. 58°,) more than four hundred miles eastward from Port Chalmers, Vancouver says:—

"He also states, that in his last excursions several places were seen, where the ocean was evidently encroaching very rapidly on the land, and that the low borders extending from the base of the mountains to the sea side, had, at no very remote period of time, produced tall and stately timber; as many of their dead trunks were found standing erect, and still rooted fast in the ground, in different stages of decay; those being the most perfect that had been the least subject to the influence of the salt water, by which they were surrounded at every flood tide: Such had been the encroachment of the ocean on these shores, that the shorter stumps in some instances at low water mark, were even with or below the surface of the sea. The same appearance had been noted before in Port Chalmers, and on this occasion Mr. Whidbey quotes other instances of similar encroachments, not only in Prince William's Sound, but also in Cook's Inlet, where he observed similar effects on the shores."

Dr. J. G. Cooper, in the Natural History of Washington Territory, makes the following note:—"On the tide meadows about Shoal Water Bay, dead trees of this species (*Thuja Gigantea*) only, are standing, sometimes in groves, whose age must be immense though impossible to tell accurately. They

* A Voyage Round the World, and to the North-West Coast of America. London, 1789.

† Op. cit. Vol. IV., p. 53.

evidently lived and grew when the surface was above high-water level, groves of this and other species still flourishing down to the very edge of inundation. But a gradual slow sinking of the land (which seems in places to be still progressing, and is perhaps caused by the undermining of quicksands) has caused the overflow of the tides, and thus killed the forests, of which the only remains now left are these cedars. This wood is perfectly sound, and so well seasoned as to be the very best of its kind. Continued and careful examination of such trees may afford important information as to the changes of level in these shores. That these have been numerous and great is further shown by alternating beds of marine shells, and of logs and stumps, often in their natural position, which form the cliffs above the bay to the height of 200 feet. But while these remains show that the changes took place in the latest periods of the Miocene tertiary epoch (?) there is no evidence in the gigantic forests still living on these cliffs, that any *sudden* or *violent* change has occurred since they began to grow—a period estimable rather by thousands than by hundreds of years."

The testimony of a small change toward depression within the last ninety or one hundred years appears concurrent.

The various Indian tribes of the coast and interior, like all peoples, have their stories, more or less unreal and grotesque, of deluges, or *the* deluge. The Okanagans, for instance, who inhabit the southern part of the interior, in a long rambling story relating their first arrival in the country which they now inhabit, are said to state* that, "after paddling day and night for many suns, they came to certain islands, whence steering through them, they came at last to where the mainland was, however much smaller than in these days *having grown much since.*"

That they had been made familiar by tradition or experience with change of the sea level is apparent from the statement of Mr. Gibbs,† that on occasion of a slight earthquake shock, the Indians of Whidbey Island, in the Strait of Georgia, in reply to an enquiry if they knew what it was, said that the "earth was rising."

The most remarkable Indian tradition, however, quite equal in its way and in the circumstantiality of its details, to the

* Bancroft, Native Races of the Pacific States, Vol. III., p. 154.

† Loc. cit. p. 359.

Chaldean account of the deluge lately unearthed, has been found by Mr. J. G. Swan among the Makah Indians of Cape Flattery, the southern point at the entrance to Juan de Fuca's Strait. This, though no doubt much exaggerated, probably embalms the memory of some real event, either of the nature of an earthquake wave, or depression and reelevation due to the not yet wholly extinct volcanic forces of the coast.

Mr. Swan writes *:—"A long time ago," said my informant, "but not at a very remote period, the water of the Pacific flowed through what is now the swamp and prairie between Wäach Village and Neeah Bay, making an island of Cape Flattery. The water suddenly receded, leaving Neeah Bay perfectly dry. It was four days reaching its lowest ebb, and then rose again without any waves or breakers, till it had submerged the Cape, and in fact the whole country except the tops of the mountains at Clyoquot. The water on its rise became very warm, and as it came up to the houses, those who had canoes put their effects into them, and floated off with the current, which set very strongly to the north. Some drifted one way some another; and when the waters assumed their accustomed level, a portion of the tribe found themselves beyond Nootka, where their descendants now reside, and are known by the same name as the Makahs in Classet (Cape Flattery) or Kwenaitchechat. Many canoes came down in the trees and were destroyed, and numerous lives were lost. The water was four days regaining its accustomed level." The same story is preserved by the Kwilléyutes, who say that part of their tribe floated to the region near Port Townsend, where their descendants are known as the Chemakum Indians. The latter again claim to have originally sprung from the Kwilléyutes. Mr Swan adds:—"There is no doubt in my mind of the truth of this tradition. The Wäach prairie shows conclusively that the waters of the Pacific once flowed through it; and on cutting through the turf at any place between Neeah Bay and Wäach, the whole substratum is proved to be pure beach sand. In some places the turf is not over a foot thick; at others the alluvial deposit is two or three feet."

Leaving, however, the realms of tradition, the conclusions provisionally arrived at, as to the former levels of the coast, may thus be summed up.

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* Indians of Cape Flattery, 1869, p. 57.

Miocene Period.—Immediately succeeding considerable mountain upheaval, and closed by basalt flows of the interior. Coast at least during part of this period somewhat lower than at present.

Pliocene Period.—Land elevated at least about 900 feet above the present sea line for part or the whole of this period.

Glacial Period.—At one or more epochs during this period land much depressed; at one time probably over 5,000 feet.

The country considerably below the present level when the glacier of the Strait of Georgia finally retreated from the south-eastern part of Vancouver Island.

Post Glacial and Modern.—Reelevation to height probably 200 or 300 feet greater than at present, followed by depression to near the present level, with probably many changes of small amount, and perhaps one or more rather important movements as indicated by the Indian stories. Lastly, somewhat rapid depression of perhaps ten or fifteen feet during the latter part of last century, a movement which may still be slowly going on.

Subsequent examination of this part of the Pacific coast may enable us to add many details to this necessarily somewhat imperfect scheme.

MISCELLANEOUS.

A Very Rare Bird.—Yesterday Mr. Vennor was so fortunate as to purchase from a Canadian in the Bonsecœur Market, Montreal, a beautiful frozen specimen of the *dark variety* of the Gyrfalcon. This is a very rare bird, and one that is being at present much discussed by our leading American Ornithologists. Up to the present only two other specimens have been taken in Canada, so far as known, and these are in our Museum of Natural History. Apart from these, there is one specimen in the National Museum of Washington, one in the Boston Museum and two in the collection of Mr. Boardman of St. Stephen's. These, with Mr. Vennor's recently procured specimen, make a sum total of but seven individuals of this species known in collections in the whole of North America. Great enquiries have been made by United States naturalists for this bird *in the flesh*, as it is yet undecided whether it is a *valid* species or merely a dark stage of the ordinary form of Gyrfalcon of Iceland and Greenland. For these reasons Mr. Vennor has transmitted the bird entire to Boston, where such men as Brewer, Allan, Deane, Bailey and other leaders in American Ornithology will study its anatomy in detail, and probably arrive at some important conclusions. The specimen, however, is not to be lost to our Canadian collections, but when preserved and mounted by a skilful taxidermist will be returned to Montreal.—Ed. *Can. Nat.*

March 15th, 1877.

Note on a Specimen of Diploxylon, from the Coal formation of Nova Scotia.—By J. W. Dawson, LL.D., F.R.S., F.G.S.—The author described the occurrence in Coal-measure sandstone at the South Joggins of an erect stump of a Sigillarian tree 12 feet in length. It originated in a coaly seam 6 inches thick, and terminated below in spreading roots; below the coal seam was an under-clay 3 feet 4 inches thick, separating it from an underlying seam of coarse coal. The stem, which tapered from about $2\frac{1}{4}$ feet in diameter near the base to $1\frac{1}{4}$ foot at the broken end, was a sandstone cast, and exhibited an internal axis about 2 inches in diameter, consisting of a central pith cylinder, replaced by sandstone, about $\frac{2}{5}$ inch in diameter, and of two concentric coats of scalariform tissue, the inner one $\frac{1}{25}$ inch

in thickness, the outer constituting the remainder of the axis. The scalariform tissue of the latter was radially arranged, with the individual cells quadrangular in cross section. A few small radiating spaces partially filled with pyrites obscurely represented the medullary rays, which were but feebly developed; the radiating bundles, passing to the leaves, ran nearly horizontally, but their structure was very imperfectly preserved. The cross section when weathered, showed about twenty concentric rings; but these under the microscope appeared rather to be bands of compressed tissue than true lines of growth. The thick inner bark was replaced by sandstone, and the outer bark represented by structureless coal. On a small portion of one of the roots the author traced the remains of stigmarioid markings. From the above characters the author identified this tree with *Diploxylon* of Corda, and stated that it was the first well-characterized example of this type of Sigillarians hitherto found in Nova Scotia. The author compared the structure of this stem with that of other Sigillarians, and remarked that it seemed to come within the limits of the genus *Sigillaria*, but to belong to a low type of that genus approaching *Lepidodendron* in structure; those of the type of *S. elegans*, Br. and *S. spinulosa*, Renault, being higher in organization, and leading towards the still more elevated type described by him in 1870. He further discussed the supposed alliance of these trees with Gymnosperms, and the probability of the fruits known as *Trigonocarpa* being those of *Sigillaria*, and expressed the opinion that the known facts tend to show that there may be included in the genus *Sigillaria*, as originally founded, species widely differing in organization, and of both Gymnospermous and Acrogenous rank.—*Proc. Geol. Soc., Lond.*

At its last session, the American Congress made an appropriation of $18,000 for a Commission of three skilled Entomologists to investigate and report on the ravages of the Rocky Mountain locust, and to suggest means for their prevention; to be appointed by the Secretary of the Interior.—*Am. Nat.*

We have received a preliminary announcement of a Scientific Expedition around the World, organized on rather a unique plan, to be conducted by a faculty of ten. There will be accommodation for sixty to eighty students. For farther information we would refer our readers to James O. Woodruff, Indianapolis, Ind., or Prof. W. L. B. Jenney, Chicago, Ill., or Prof. J. B. Steere, Ann Arbor, Mich.—*Ibid.*

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THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

OBITUARY NOTICE OF ELKANAH BILLINGS, F.G.S.

Palæontologist to the Geological Survey of Canada.*

By J. F. Whiteaves.

The founder of this journal, whose loss we have so recently had to deplore, was the second son of Mr. Bradish Billings, whose farm and dwelling were situated on the east bank of the Rideau River, in the township of Gloucester, some three miles distant from Bytown, or Ottawa as it is now called. About a hundred yards to the south of his residence, Mr. Billings built a bridge across the river, and the circumstance is commemorated by the name still borne by the little village which has recently sprung up around it.†

Including two who died in their infancy, there were nine children in all, but of these only two showed any very decided taste for natural history studies, viz. Bradish, the eldest, who died in 1872, having previously gained some reputation as a botanist and entomologist, and the subject of the present memoir. In answer to some inquiries as to the early history of the family, the youngest son, Mr. Charles Billings, writes as follows: "My father's maternal ancestors came from Wales and those on his father's side from England: the name Billings is of Saxon origin

* Altered slightly from a paper read before the Natural History Society of Montreal, on the 27th of November, 1876.

† Billings' Bridge.

and exhibits two separate coats of arms in the book of heraldry. My mother, whose maiden name was Lamira Dow, was, I think, of Irish extraction on her mother's side and of Scotch on her father's, so you see we have pretty nearly the whole British Empire at our backs. My grandfather was a Dr. Elkanah Billings who settled near Brockville and practised there until he died. My father was born in the State of Massachusetts and my mother in the State of New York."

Elkanah Billings, our esteemed associate for so many years, was born at the family homestead, on the fifth of May, 1820. His first teacher was a governess (Miss Burrit) his next a family tutor named Maitland, and he afterwards went to three small schools in the neighbourhood kept respectively by Messrs. Colquhoun, Collins and Fairfield. In 1832 the youth was placed at the Rev. D. Turner's school in Bytown as a day pupil, and after a four years' interval, during which he remained at home on the farm, his parents sent him in 1837 to the St. Lawrence Academy at Potsdam in the State of New York, of which the Rev. Asa Brainard was principal.

On leaving this institution Mr. Billings entered the Law Society of Upper Canada as a student in 1839 and was articled to Mr. James McIntosh, a barrister in Bytown. Mr. McIntosh died in the same year and was succeeded by Mr. Augustus Keefer, with whom Mr. Billings remained for nearly four years; and it appears that he was for a short time also in the office of the late Mr. George Byron Lyon Fellowes, in the same town. In 1843 he went to Toronto and studied for a twelvemonth longer with the legal firm of Baldwin & Wilson, and was admitted to practice as an attorney in the fall of 1844. Soon after this he returned to Bytown and entered into partnership with Mr. Christopher Armstrong, who was then one of the judges of the County Court, but a law having been passed prohibiting judges from pleading, the partnership was dissolved after having lasted only six months.

In the summer of 1845 Mr. Billings went to Toronto where, having first been called to the bar, he married a sister of Mr. Adam Wilson, the junior partner of the firm previously mentioned, now the Hon. Judge Wilson. From August 1845 until about the end of 1848 he practiced his profession in Bytown partly alone and partly in partnership with Mr. Robert Hervey. In 1849 he removed to Renfrew, and remained there, still practic-

ing as a barrister, until the 10th of June, 1852. The following day he returned again to Bytown, and here though he opened an office ostensibly to pursue his professional calling, he practically deserted it to a large extent to follow that of a journalist. In those days there were two newspapers in Bytown the "Citizen" and the "Gazette." The editorial chair of the one was occupied by Mr. Billings,* that of the "Gazette" by a Mr. Gibb. A wordy war not unfrequently arose between the champions of the rival papers, like that which raged between the editors of the Eatanswille Gazette and Independent as chronicled in the pages of Pickwick. On one occasion Mr. Billings' effusions were more forcibly than politely spoken of as "Billingsgate" in the columns of the Gazette, and Mr. Gibb's utterances in their turn were contemptuously summed up as "Gibberish." Many of Mr. Billings' leaders in the Citizen, however, were in a very different vein, being popular articles on geological topics, and these are interesting as illustrative of the commencement of a new mental phase in the writer's existence. They shew the enthusiasm of a student just entering upon a new world of inquiry, who has first begun to catch glimpses of his true vocation. They are marked, also, by the absence of that extreme caution which characterized some of his later efforts. First law, then journalism, each in its turn were gradually absorbed by, or rather forsaken for, what ultimately became the ruling passion of his life. The fossiliferous Silurian rocks of the banks of the Ottawa soon had greater charms for him than the tedious routine of the district courts, or the editing of a newspaper over whose columns he had no control. Whilst practising at the bar, his keen sense of justice was often wounded by what seemed to him unjust juridical decisions, and it is said that he once barely escaped being indicted before the Grand Jury by his former partner Judge Armstrong for remarks published in the "Citizen" reflecting on one of his judgments.

Most of Mr. Billings' time between 1852 and 1856 was employed in the collection of the organic remains of the Lower Silurian rocks near Ottawa city, and he obtained, in particular, a fine and unique series of Crinoids, Cystideans and Star-fishes, which are now in the Museum of the Geological Survey. On

* Apparently from the fall of 1852 until the close of 1855, though the writer has not been able to ascertain the exact dates at which Mr. Billings' connection with that newspaper began or ended.

the seventh of January, 1854, he was elected a member of the Canadian Institute of Toronto, and in the same year his first purely palæontological paper was published in that society's journal. It was entitled "On some genera and species of Cystidea from the Trenton Limestone," and was issued in two parts.

In 1855 a committee was appointed to endeavour to secure a creditable representation of the products and industrial resources of the country at the first Paris Exhibition, and prizes were offered for the best essays on Canada. The first of these prizes was adjudged to John Sheridan Hogan (whose tragic fate in Toronto may be remembered by some of the readers of these pages), the second to the Hon. Alexander Morris, the present Lieutenant-Governor of Manitoba, and the third to J. C. Taché, M.P.P. In accordance with the recommendation of the Judges, the executive committee awarded three extra prizes, of twenty-five pounds each, to the authors of the essays bearing the following mottoes: "Suam quisque pellem portat"; "Reddit ubi cererem tellus inarata quotannis"; and "It is with nations as with nature, she knows no pause in progress and development, and attaches her curse to all inaction." The authors of these essays were declared to be Hector L. Langevin, of Quebec; E. Billings, of the city of Ottawa; and W. Hutton, secretary to the Board of Statistics, Quebec.

The first number of the *Canadian Naturalist* was issued by Mr. Billings in February, 1856, with a prospectus shewing the objects aimed at in the new venture. A copy was sent to each of the members of Parliament, and one was also forwarded to Sir W. E. Logan, accompanied by a letter, of which the following is a copy:

OTTAWA, 29th February, 1856.

SIR KNIGHT,

I have taken the liberty of sending you the first number of the *Canadian Naturalist and Geologist*, and hope that it may find favour in the opinion of one who has achieved so much for science in this province. It is scarcely necessary to say to you that a work commenced under the circumstances cannot be without imperfections. I feel satisfied, however, that with practice and perseverance I can improve its appearance. You are aware that during the last few years I have been studying geology,* and during last summer I

* With the view of qualifying himself for a field geologist, he had also at this time mastered the first principles of optics and trigonometry, as the writer learns from the perusal of other letters to Sir W. Logan.

also connected zoology with it (principally the mollusca and reptilia of the country), and have learned that the youth of Canada little know how full of curious and beautiful objects the whole of this fine province is. The object of my magazine is to place within the reach of my young countrymen as much of that knowledge which is necessary to examine for themselves, as I can collect. They are not without talent and taste for the study of nature, but they are yet without the key to her stores. I have abandoned my profession, and intend to devote the rest of my life to the study of Natural History. I have commenced the publication of this magazine partly as a means of subsistence, and partly for the purpose of arousing, if possible, the youth of this country to pursuits for which they have everywhere most unrivalled facilities. *I am well aware that I shall have great difficulties to encounter, but I can overcome them as I have done others.* I hope you will agree that the object is at least good, and as for its execution—this must be left for me to work out as well as I can. Allow me to state that no man here yet received the order of knighthood with so much satisfaction to the people of this part of the country as yourself, a view in which no person can concur more heartily than I do.

I have the honour to be,
Sir,
Your very obedient servant,
E. Billings.

The latter part of the sentence italicised above is very characteristic of the man, who, whatever may have been his other deficiencies, was certainly not lacking either in energy or industry. It is almost superfluous to mention the fact that Mr. Billings was not only the originator but also the proprietor and editor of the "Naturalist" during the first year of its existence, for his name appears on the title-page of every number. In the first volume there are sixty-three articles, and of these no less than fifty-five were either written or compiled by him. They are all penned in a simple easy style, and being intended principally for the perusal of persons unacquainted with Natural History, are as free from technicalities as the nature of the subject would admit. Twenty-two of them contain plain descriptions of the habits and structural peculiarities of Canadian mammals; fourteen are on as many species of native birds; and all are supplemented by quotations from Wilson, Audubon, and other naturalists. Ten are devoted to the illustration of characteristic fossils of various strata in both provinces, and the rest are on general topics, though mostly connected with geology. The receipts arising from the sale of this volume were insuffi-

cient to defray the expenses of its publication, and Mr. Billing's self-sacrificing efforts to promote the diffusion of knowledge under such discouraging circumstances should be remembered with gratitude by every lover of Natural History in the Dominion.

Between the years 1852 and 1856 a regular correspondence had been kept up between Mr. Billings and Sir W. E. Logan, and in the latter year Sir William succeeded in obtaining for his friend the position of Palæontologist to the Geological Survey of Canada. This of course necessitated an immediate change of residence, and Mr. Billings accordingly removed to Montreal, and entered on the discharge of his new duties on the first of August, 1856. His first two months at the Survey were occupied, as he states in his first official report,* in a general examination of the large collection of fossils in the Museum, with a view to their final arrangement for the purpose of public exhibition.

Early in October of the same year, Mr. Richardson returned from Anticosti, bringing with him an extensive series of the fossils of that island, and shortly afterwards Mr. Billings examined these specimens together with Prof. James Hall of Albany, who happened to be on a visit to Montreal at the time. The report previously cited contains an analytical review of the palæontological relations of the Anticosti rocks, and descriptions of a large number of new species of Silurian fossils, principally crinoids, cystideans, and star fishes, from the Trenton limestone, and mollusca from Anticosti.

In August, 1857, the American Association for the Advancement of Science held its annual meeting in Montreal, and every effort was made both by Sir W. Logan and Mr. Billings to make as creditable display as possible of the collections in the Survey Museum for the inspection of the expected visitors. Among the eminent men of science who attended this meeting was Prof. A. Ramsay, of the Geological Survey of Great Britain, who was deputed to represent the Geological Society of London, and whose acquaintance Mr. Billings then made for the first time. The months of September and October, 1857, were employed in two short collecting expeditions. In the first, the Black River

* Geological Survey of Canada, Report of Progress for the years 1853-54-55-56, page 247.

and Trenton limestones of Jessups Rapids and of Lake Clear in the valley of the Bonnechere were examined, in company with Mr. J. McMullen, as was also the Chazy limestone of Golden Lake, in the same district. Next, the village of Trenton, in the State of New York, was visited, after which Mr. Billings proceeded to Belleville and Shannonville, and from thence to Guelph, Galt, Dundas, Hamilton, Thorold, Port Colborne, and Cayuga. Large collections of fossils were made at each of these localities, many of which were described and figured in his report for that year.

His first and only visit to Europe was made in 1858. Leaving Canada late in January, he landed at Liverpool on the 11th of February, and after a three days detention at that port, arrived in London on the 15th. The objects of this journey were threefold: first, to superintend the illustration of Decades Nos. 1 and 3 of "Canadian Organic Remains" * in London; secondly, to compare a number of fossils from the Survey collection, which he took with him, with types in European museums; and thirdly, to endeavour to secure the services of a professional artist for the staff in Montreal. At the Museum of Practical Geology in Jermyn Street, he was introduced by Prof. Ramsay to all the officers of the Geological Survey of Great Britain, and a work room was set apart for his special use. He took lodgings in Montpelier Square, Brompton, and carefully studied the Silurian and Devonian invertebrates in the public collections of the metropolis. With the late lamented S. P. Woodward he critically examined the Canadian fossils in the British Museum collected by Dr. Bigsby and others and described by Stokes, and compared them with specimens recently brought by Prof. Hind from the Saskatchewan district. The two species of Beatricea collected by Mr. Richardson at Anticosti had been previously described by Mr. Billings as plants, and specimens of each were submitted to Dr. Hooker at Kew, who finally concluded that they did not belong to the vegetable kingdom. Salter at the time maintained that they were the tracks of some gigantic annelid, but this view does not seem to have been received with much favor by palæontologists. During his stay in London, Mr. Billings went to a conversazione at Sir Roderick Murchison's, and on another occasion had a long conversation with the late Lord Palmerston in the

* Then in process of publication.

galleries of the Jermyn Street Museum. In a letter to Sir W. E. Logan, dated London, April 19th, 1858, he says, "since I have been here I have examined, I may say, thousand of specimens of Silurian and Devonian fossils in the different museums and am astonished to find so few that are identical with our own." Contrary to my expectations, the number of species common to the two sides of the Atlantic must be reduced instead of increased." Of course the "our own" in this case applies only to the two Provinces now called Ontario and Quebec. In April of this year he was elected a Fellow of the Geological Society of London, the signers of his certificate previous to the election being Sir Roderick Murchison, Prof. A. Ramsay, and Prof. Huxley. Soon after this he attended the annual dinner of the Society, respecting which he wrote to Sir W. Logan, as follows: "the Royal Hammerers had a jolly dinner a few days ago, I was there. Your health was drunk and Ramsay made a great speech in praise of our Survey. I returned thanks. Sir Roderick Murchison was in the chair." Previous to his departure from England he paid a short visit to Paris and inspected the Palæozoic corals described by Edwards and Haime; here too he met the great Bohemian palæontologist, Barrande. At the suggestion of Prof. Huxley, Mr. Billings induced Mr. Horace S. Smith to accompany him on his return voyage to Canada and to accept the position of artist to the Survey. Accordingly they sailed from Liverpool on the 2nd of June and arrived together in Montreal on the 15th of that month.

Except on an occasional visit to some fossiliferous locality not far distant from the city, Mr. Billings scarcely ever left Montreal after this journey across the Atlantic, but devoted himself sedulously for the remainder of his life to the study and description of the fossils in the Survey collection. The titles of his writings since 1858 are too numerous to quote in full, yet they afford the only true index to his intellectual labours from this date. His most important separate memoirs are monographs on the Cystidea, Asteroidæ and Crinoidea of the Lower Silurian rocks of Canada, in decades Nos. 3 and 4 of Canadian Organic Remains," Montreal, 1858–59; Palæozoic Fossils, Vol. I, Montreal, 1865; also Vol. 2, Part 1, Montreal, 1874; and "Catalogues of the Silurian Fossils of the Island of Anticosti, with descriptions of some new genera and species," Montreal, 1866. From first to last he contributed no less than ninety-three

articles to the "Naturalist," and besides numerous official reports in the publications of the Survey, he wrote valuable papers for the Journal of the Canadian Institute of Toronto, for the American Journal of Science and Arts, and for the Geological Magazine of London. He was awarded a bronze medal in Class 1 by the jurors of the London International Exhibition of 1862, and a similar one at the Paris Exposition Universelle in 1867.

For three years before his death, Mr. Billings' state of health was such as to cause grave uneasiness to his friends. Slowly and insidiously his originally vigorous constitution was undermined by that affection of the kidneys known as Bright's disease to which he ultimately succumbed on the morning of the 14th of June, 1876.

As is the case with so many original thinkers, Mr. Billings was entirely a self-taught man, so far at least as science was concerned. The success of his career as a palæontologist—and that it was a success can scarcely be doubted—was largely due to the concentration of his mind on one object. To this must be added the possession of analytical powers of mind of a high order, which enabled him to discriminate readily between specific or generic distinctions as opposed to merely individual differences. In his knowledge of the invertebrates of the Lower Palæozoic rocks of Canada he had no equal, though his weakest point was unquestionably the Protozoa of these deposits. From the Silurian and Devonian formations in the Dominion he described about one thousand new species of fossils, and the frequency with which his writings are enquired for both in America and Europe, afford the best proof of the high estimation in which they are held abroad. Until his health failed him, he was to be found at his desk as early as half-past seven in the morning, and he often took his work home with him at night. He possessed a capacity for brain labour such as falls to the lot of few, and taught himself enough of German, Norwegian, Swedish, and Danish to be able to construe palæontological essays in either of these languages with ease. That he was enabled to devote twenty years of his life exclusively to the prosecution of researches for which he shewed so much aptitude, was no doubt a very great advantage, yet on the other hand he had many difficulties to contend with, especially in the earlier part of his life. Before 1856 he had access to no public collections or to any good scientific libraries, Apart from his visit to England, and he stayed

there only four months, he travelled very little. If therefore in his writings there is occasionally to be traced an inclination to make unnecessarily minute sub-divisions of strata which cannot be recognized over large areas, or to unduly multiply species, it should be remembered that his experience in the field was both limited and local; also that if life had been spared him, his intention and hope was to have revised his work.

Mr. Billings' patient elaboration of the fauna of the "Quebec Group," as exhibited in this province and in the island of Newfoundland, is a master-piece of palæontological acumen, and he is justly entitled to the credit of being the first to point out the true geological horizon of these rocks. Although, as before stated, the invertebrates of the Silurian and Devonian rocks were the objects of his special study, he was well acquainted with other branches of Natural History. His essay "on the remains of the Fossil Elephant found in Canada" shew that he was a very good comparative osteologist. It is the only paper of the kind that he ever printed, though he once read before this Society a paper on the bones of a species of Beluga dug up near Cornwall, and he has since examined and determined the nature of a few mammalian remains collected by Mr. Richardson near Victoria (V. I.) in 1874, and by Mr. Ells from the Saskatchewan district in 1875. Entomology at one time was a favourite science with him, and he made a very good collection of native coleoptera, which he presented to the museum of this Society a few years ago, in whose cabinet it is still preserved. The article "on the pine-boring beetles of the genus Monohammus," is his first and last contribution to the literature of entomology. For many years he was a zealous collector of minerals, and although he always refused to give an opinion upon specimens which might be submitted for his inspection, and never wrote anything directly bearing on the science, he was nevertheless tolerably well versed in mineralogy.

It is to be regretted that no manuscripts exist which would enable the second volume of the Palæozoic Fossils to be completed. Ever since the publication of the first part (in 1874), Mr. Billings' time was almost exclusively occupied in the study of the fossils of the Upper Silurian rocks of the eastern portion of the Dominion, more especially of those collected by Sir W. E. Logan and Prof. Bell near Cape Gaspé, by Mr. T. C. Weston at Arisaig, and by Mr. T. Curry at Port Daniel in the Bay of

Chaleurs. The whole of the material from these localities had been carefully examined, and it only remained to write the descriptions of the different species, but this, alas, he was not destined to accomplish. As it is, the only clue to the conclusions arrived at with regard to them, is the existence of labels attached to some specimens in the Museum of the Survey, with new names, proposed but not yet published, printed on them.

Mr. Billings' private character was marked by great firmness and decision, by an unswerving love of truth and justice, and by an unaffected and winning modesty of demeanour. In his intercourse with his fellow-men he was unusually reticent and reserved, especially of late years, but this was largely due to the fact that he rarely met with people who either understood the nature of his studies or sympathized with their object. That he was not devoid of geniality, many of his more intimate friends could easily testify.

It is pleasant to be able to add that this Society was one of the first to appreciate and foster Mr. Billings' peculiar talents, and that its members have never ceased their endeavours to help him in his official work. On the 25th September, 1854, the year in which he published his first palæontological paper, he was elected a corresponding member of the Society, his name having been proposed by Dr. Benjamin Workman and seconded by Mr. J. H. Joseph. On the 29th of September, 1856, a few weeks after he had accepted the position of Palæontologist to the Survey, he became a resident member. In the following year the Society relieved him of the responsibility of editing the "Canadian Naturalist," and has regularly superintended its publication up to the present time. The Council and members of the Society voted him its silver medal in 1867, by way of showing their sense of the value of his life-long efforts for the promotion of science in Canada. Since 1862 Mr. Billings has been regularly elected a Vice-President of the Association, and has frequently been pressed to accept the office of President, although he invariably declined nomination. The resolutions passed by the members at a special meeting held soon after his decease, are a tribute of esteem to his personal worth and scientific attainments, while the fine portrait by W. Raphael, now hanging in the Society's Hall, is a silent witness to their thoughtful efforts to perpetuate his memory.

NOTES ON SOME GEOLOGICAL FEATURES OF THE NORTH EASTERN COAST OF LABRADOR.

By Henry Youle Hind, M.A.

(*Continued from page* 240.)

I. Symmetrical structure of the Strata. — II. Concretionary structure. — III. Boulders and outliers of the Upper Laurentian or Labrador Series.— IV. Permanent Snow Drifts.—V. Influence of Winds on the composition of the Drifts.—VI. Mechanical effects produced by Snow Drifts.—VII. Amount of Snow fall in North Eastern America.—VIII. Direction and Force of the Winds.—IX. Influence of Snow Drifts as Geological Agents.

1.—Symmetrical Structure of the Strata.

It has been already stated that in general the structure of the North Eastern Coast of the Labrador is very symmetrical, and that the strata are often seen to be arranged in grand curves, which in some instances maintain a uniform outline for miles.

The strike of the rocks in Hamilton Inlet is about S. 75 W. and this course would carry the limestones already described to an exposure of the same rock noticed many years ago by Mr. W. H. A. Davies,* on the Grand or Hamilton River (which is the same as the Ashwanipi), some distance below Keith Lake, and 130 miles from the mouth of the river. Here, according to Davis, "primary marble of a beautiful whiteness, was seen cropping out at the edge of the water; it was found in contact with a quartz rock passing into mica slate, having crystals of common garnet embedded in it."

In sailing towards Rigoulette, and on approaching the islands called "The Sisters," the uniform foldings are specially remark-

* Trans. Lit. and His. Soc. of Quebec, 1842.

able, and the strata present themselves in enormous anticlinal and synclinal folds, which are easily traced, in some instances over half a quadrant. In numerous examples, too, the dips were found to be low, varying from 15 to 45 degrees, and the prevalence of low dips was noticed at localities a hundred miles apart, as for instance in Porcupine Bay, near to Sandwich Bay, and in Lake Melville at the head of Hamilton Inlet. At Esquimo Island, close to the mouth of the Narrows above Rigoulette, the dip was from 20 to 25 degrees, and in the vicinity of English River, for long distances, about 25 to 30 degrees. In the neighbourhood of trap intrusions the strata are necessarily disturbed, but as these intrusions appear to follow certain well defined lines, the undisturbed portions of the Lower Laurentian in and about Hamilton Inlet and Lake Melville, show a regular and symmetrical folding.

II.—Concretionary Structure.

When the ice-planed surfaces of those beds which present a dip more nearly approaching the vertical, are carefully examined, the observer is very liable to be misled, unless he follows out the apparent undulations which may arrest his attention. These are frequently found to be due to a concretionary structure on a grand scale. Small and thin lenticular beds of micaceous schist, for instance, are seen to be followed regularly by larger zones of the same rock, and the impression is conveyed that many of the supposed minor undulations are merely part of great concretionary forms.

The tendency to a lamellar arrangement of thin sheets about a nucleus, highly compressed and drawn out, is oftentimes very marked and very deceptive; it was observed in several cases to extend over more than a hundred yards in length, without a break, and probably the concretionary structure involves very much larger masses, and may not unfrequently give rise to apparent instances of supposed folding.

III.—Boulders and Outliers of the Upper Laurentian or Labrador Series.

Boulders of Labradorite and occasionally of Hypersthene, are of common occurrence all the way from Porcupine Bay to the head of Lake Melville (140 miles), in a south-westerly course.

Some of them are of enormous size; one near the mouth of English River, of Labrador felspar, was estimated to contain 8000 cubic feet; another, but of smaller dimensions, and composed chiefly of Hypersthene, was seen perched on a hill 300 feet high, at Cape Porcupine. Mr. Colchester found a boulder of chatoyant Labradorite at the summit of St. John's Island, some 500 feet above the huge erratic just described, lying near the mouth of English River, and three miles distant from it. In the valley of English River were numerous worn and also *angular* masses of Labradorite of large dimensions. Dr. Packard found domes or bosses of the Upper Laurentian series resting upon probably Lower Laurentian rocks at Square Island, which lies at the mouth of a deep bay, north of Cape St. Michael, and about eighty geographical miles south east of Cape Porcupine.*

Dr. Hunt considers that the domes of Labradorite found by Dr. Packard, not only at Square Island but also at Domino Run, as "probably nothing more than outlying portions of the newer Labrador formation resting upon the Laurentian strata." This conclusion is fortified by the occurrence of Crystalline Limestones of the older Laurentian, described in the first part of this paper, in Hamilton Inlet; and we may regard the great accumulation of Labrador felspar strewed over these older rocks, as the ruins of a vast sheet which formerly covered this part of the Labrador peninsula, and which maintains itself in great force beyond Ukkasiksalik, and exhibits a large development of the most beautiful and delicately coloured varieties in the neighborhood of Nain.

But boulders and angular masses, and masses partially worn, or pan ice-polished where exposed surfaces have been reached, are to be found all along the coast line in sheltered coves; possibly also outliers, as at Square Island and Domino Run, may be found distributed through the country between these distant points. These however, whether in position or in the form of an assemblage of loose masses, are the remnants of a formation

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* Dr. A. S. Packard—On the Glacial Phenomena of Labrador and Maine. Memoirs of the Boston Society of Natural History, Vol. I, p. 2, 1867. See also an article by Dr. Sterry Hunt "On Norite or Labradorite Rock," read before the American Association for the Advancement of Science at Salem, Aug. 1869.

which is recognized at intervals as far south as Massachusetts, and as far east as St. George's Bay in Newfoundland. Its pre-eminently felspathic character causes it to be greatly subject to joints, and susceptible of cleavage. Its wear and waste has been much facilitated by these characteristics, and the removal appears to have been accomplished to some extent in recent geological times, and through the instrumentality of *snow* as a first or leading cause, followed by the propelling and abrading power of *pan ice*.

IV.—Permanent Snow Drifts.

Sailing in a north-westerly direction, near the Atlantic coast of the northern part of Newfoundland, and thence on to the Labrador, the permanent patches of snow which occasionally show themselves in the mountains, increase in numbers and dimensions, until on arriving in the latitude of the Mealy Mountains (54° N.) they form a constant and marked feature in the aspect of the country.

These snow patches are drifts of great extent occupying ravines or valleys in the mountain sides, and they vary from a few square yards to many hundred acres in extent, generally increasing in area with the altitude. The mountain ranges on the Labrador, between Sandwich Bay and Ukkasiksalik, trend from north-east by east to south-west by west. The Mealy Mountains, as seen on the coast near Sandwich Bay, do not exceed 1500 feet in altitude, according to the Admiralty chart, but on the south shore of Lake Melville they attain an estimated elevation of between 4000 and 5000 feet, and are very imposing in their peaked and serrated outline.

On the northern side of Hamilton Inlet and Lake Melville are the Kokkok Range, the Fox Mountains and the China Range, which, with some detached peaks, give to the whole of that part of the country a rugged and elevated character. The Kokkok mountains, as seen from Lake Melville, were thought to be fully as high as the Mealy Mountains, and the Salt-water Lake Range or Toush-ia-lik Mountains, which lie north of the Fox Range, may next approach them in altitude. On all of these separate ranges permanent snow patches exist. These masses, which in some particulars have a glacial character, diminish in size during the summer, until the first snow storms in September, but they always form a marked feature in the scenery, and according to

the Esquimo and residents on the coast, are permanent; some years appearing larger in August than during other seasons, but always there. In a stretch of a hundred miles one sees perhaps the same number of permanent snow patches, until Cape Mokkovik or Aillik is past, when they become more frequent, and reach much lower down the hill sides, in fact actually descend to the shore on the range which terminates at Cape Hurricane (lat. 55° 50′).

The snow drifts on the coast line—some of them covering many hundred acres in area—maintain themselves without much apparent diminution in size during August and part of September, even when their base is but a few feet above the sea level. Farther in the interior the bases appear to rise in vertical altitude above the sea with the increase of temperature, and probably they may disappear altogether farther inland, below an elevation which is still very considerably lower than the snow line, especially if the country should be wooded, or no surface features exist which would permit of the growth of drifts.

The coast climate, deriving its severity and humidity from the Labrador current, reduces the mean temperature to such an extent as to permit snow drifts of certain dimensions to remain throughout the year on exposed fronts facing the south-east or east, which is generally the *lea side* on the Labrador. There is thus a zone existing for hundreds of miles on this coast throughout which permanent snow drifts in valleys and ravines prevail to a large extent, and the aggregate area they occupy in August gradually increases as we progress towards the north-west.

The breadth of this zone varies with the mountainous character of the country, and is especially dependent upon forest growth. Where there are unbroken forests, however stunted, there are no permanent drifts. Hence conflagrations, destroying forests, tend to foster the growth of snow drifts and their disintegrating and polishing work.

V.—Influence of Winds.

Apart from the reduction of temperature on and near the coast line, due to the constant presence of the cold current, there is superadded the prevalence of strong north-westerly winds for a considerable part of the year, which not only occasion the snow drifts, but from their low temperature and moisture preserve them.

I had time and opportunity to examine with care one only of the drifts or snow banks on the coast line south of Hamilton Inlet. It lay under the lea of a huge wall of ice-polished trap, on a plateau about 100 feet above the sea level. It was remarkable at a distance owing to a belt of vivid green at its base, bordered by a dark band gradually fading off into a grey, which blended with the white of the snow above it. Climbing to the edge of the green stripe, it was found to consist of a deep and luxuriant growth of moss and grass. The dark belt succeeding was found to be a layer of fragments of peat and particles of sand with a few pebbles, resting upon snow, and driven there by the wind. The grey band succeeded by stainless snow, consisted of smaller bits of peat with a little sand and a few pebbles sunk into the snow. The whole mass was evidently slowly moving to the edge of the cliff which terminated the plateau, and pushing before it a small belt of accumulated debris. Its breadth was about 60 feet, its length may have been 250 feet, but its depth could not be ascertained with the appliances at hand.

This snow bank was an illustration on a very small scale of numerous larger drifts seen farther to the north-west, and a pigmy compared with the giant drifts filling ravines and valleys on the mountain sides. Generally it may be said that nearly every ravine on the slope of the range which terminates at Cape Hurricane, had its permanent snow drift, with accumulated layers of wind-blown sand, small pebbles, and fragments of peat, the whole mass slowly sliding towards the beach, and some of them within a few feet of the wave-washed base of the hills.

VI.—Mechanical Effect of Snow-Drifts.

Personal experience does not enable me to describe the mechanical effects of the larger drifts which are found farther to the north, but the testimony of Mr. Lieber, who accompanied the United States Solar Eclipse Expedition to Eclipse Harbour in 1860, supplies the information respecting snow-drift work beyond Cape Mugford. Mr. Lieber describes the slopes of Mount Bache in Eclipse Harbour, lat. 59° 48′ as covered with loose angular blocks. Mount Bache rises 2150 feet above the sea level, and so strewed was its summit and sides with "unchanged blocks of gray gneiss" being part of the solid strata

beneath them, that the uptilted beds of the parent rock *in situ* were seldom seen. "Clearly," says Mr. Lieber, "that force which had riven its beds asunder, no other than the frost, had broken the rest from their foothold and prepared them for removal by another coming into play at a later season; the thawing down-gliding *snow*." "Many of the blocks were probably but slightly removed from their original position, perhaps barely turned over or merely forced a little out of place. Yet the effect to the eye of the beholder would be as great as if they had been transported hundreds of miles."

"When we descended from the mountain we crossed over a broad patch of snow, deeply packed, twenty feet deep, which clearly taught us how the blocks were moved. In truth this was a miniature glacier, and a regular moraine was piled up along its edges. It is impossible for us to form any estimate of the amount of snow which may fall per square foot in a winter, but from the fact that such quantities were still remaining late in July, and certainly they never altogether thaw away, we may reasonably infer that during its downward progress, either as snow or water, a tremendous force must be exerted, a force quite sufficient to account for the characteristic surface phenomena just described."

Scoresby's account of the effects of frost on the rocks of Spitzbergen, agrees with Mr. Lieber's descriptions. This enterprising discoverer and observer notices also the movements of masses of broken rock down the steep sides of hills, when disturbed, and their bounding down the declivities and lodging in a bank of snow, two thousand feet below his point of observation.

Angular blocks of gneiss and other rock species are constantly met with on the Labrador in protected valleys, such as English River, and they may also be seen in Newfoundland and elsewhere in much lower latitudes, pointing to the separation of the blocks at the joints by alternate freezing and thawing, and their probable subsequent movement by means of snow. It is to the polishing and striating effects of snow drifts that I would also wish to direct attention.

There is on the Labrador no "soil cap" to produce the motion of blocks of strata recently described by Sir C. W. Thomson in the February number of '*Nature*,' but there is, nevertheless, a powerful agent in snow and wind combined, in

not only denuding rock masses, but also in moving the debris down the least slope which can give motion to a snow bank.

We are apt to underrate the mechanical effects of snow when we see it uniformly spread, as in Canada, over the surface, where trees prevent drifting; but when high winds, combined with a snow fall of six to ten feet is piled in great masses on the lea side of hills, it becomes a mechanical agent possessing enormous power constantly acting, if the drift be permanent. Even at the present day the snow fall throughout much of the forest covered portion of British North America, forms a sheet, as we shall presently see, averaging six feet in thickness, and constitutes a true snow zone. If this sheet could be gathered into great wind-rows, as it really is on the exposed and treeless Labrador coast, its mechanical force would be called into play in a very striking manner.

VII.—Amount of Snow-fall in North-Eastern America.

The snow-fall on the coast of North-Eastern Labrador is very considerable, but not nearly so great as one would suppose from the vast accumulations on lea slopes and in ravines facing the east or south-east. As far as I could gather from the accounts of the Missionaries, Esquimo and resident trappers on the coast, the snow does not, in general, exceed eight feet in the woods, when it is protected from winds. Judging by this rude method, the annual snow-fall may average some thirty or forty inches more than in the Maritime Provinces of the Dominion, or some parts of Ontario. But this zone of snow, even when we confine its limits to a depth not more than five feet on the level or about 60 inches, allowing for evaporation, is a power, when moved by winds and thrown into drifts, which, under favourable circumstances, exercises an influence in moulding the outline of the surface to an extraordinary extent, and is strictly comparable with the more striking, because concentrated effects, of other forms in which frozen water or vapour is seen to act.

But a snow drift remaining throughout the year on an exposed slope, and slowly, almost imperceptibly, gliding down to a lower level, affords of itself no measure of the mechanical work it directly effects by gravity and motion. It is a never-ceasing agent for condensing the vapour of the atmosphere, and to the mechanical effect it produces by its own weight as snow, must be added the effect produced by the moisture it condenses from the

air, throughout the entire period of its existence. Mr. G. P. Marsh * draws attention to the observations made in Switzerland on the hygrometric functions of snow in relation to the condensation of atmospheric vapor by the snows and glaciers of the Rhone Basin. It is estimated that the total of this condensation is nearly equal to the entire precipitation of the valley. There can be no doubt that permanent snow drifts on the Labrador condense an immense amount of moisture, which must find its outlet during the summer months in the counterpart of miniature glacial rivers, and these proceeding from a snow drift a square mile in area, will be no insignificant streams. There are very many such drifts on the N. E. Labrador coast.

The following tables show the existence of a great snow zone in North America stretching far down into temperate latitudes, which is doing extensive geological work on the Labrador. It there represents a modern and existing continuation of work formerly done over wide-spreading areas farther to the south, and in its mode of operation it represents, in innumerable miniature forms, the action of alpine glaciers, and is yet thousands of feet below the line of perpetual snow, in the ordinary acceptation of the term.

1. *Table showing the Annual Snow Fall in the several Provinces of the Dominion of Canada, and in Newfoundland.*†

IN INCHES.

Provinces.	1873.	1874.	1875.
Ontario	101	75	97
Quebec	152	107	123
New Brunswick	132	106	126
Nova Scotia	110	86	104
Prince Edward Island	124	127	136
Newfoundland	116	100	196
Manitoba	40	63	41

* "The Earth as Modified by Human Action." By George P. Marsh. New York, 1874.

† These tables are framed from the data contained in the extensive and important series published under the supervision of Professor Kingston at Toronto, in the Reports of the Meteorological Office of the Dominion of Canada.

The difference between the annual depth of snow which falls in the interior continental Province of Manitoba and the Maritime Provinces of the Dominion, is very marked, but this difference fails to convey a correct idea of the snow fall on the coasts of the Gulf of St. Lawrence and the Atlantic. There is a snow zone there, where the average depth each year does not fall short of ten feet, and sometimes the total fall approaches double that great precipitation of snow, as for instance at Quebec in 1873.

2. *Table showing the amount of Snow-Fall at Stations on Lake Ontario and the St. Lawrence, the Gulf of St. Lawrence, and the Atlantic Ocean.*

IN INCHES.

	1873.	1874.	1875.
Lake Ontario and the St. Lawrence.			
Toronto	114	67	107
Brockville	123	86	135
Montreal	145	119	115
Quebec	237	150	182
Gulf of St. Lawrence.			
Chatham	....	115	162
Dalhousie	....	75	148
Atlantic Coast.			
Halifax	103	89	87
Sydney	142	126	138
Newfoundland.			
St. John's	116	138	169
Harbour Grace	....	122	137

We see that on the Gulf Coast, in the Lower St. Lawrence, and on the Atlantic Coast from Cape Breton northwards, the annual snow fall at some stations, occasionally reached twelve feet in vertical depth of fall as measured in the ordinary way. When settled, as in forests in the spring, it often measures five feet in depth, sometimes six feet, or about half the registered fall.

If we take the total precipitation for the year for the several stations named, it will be observed that geographical position and altitude above the sea, has a great influence, even in a limited area, in determining whether the precipitation takes place in the form of rain or snow, consequently these data are all important in estimating the probable geological effects of snow, when such conditions prevail as to permit it to remain in the form of permanent drifts.

3. *Table showing the Total Annual Precipitation in the several Provinces of the Dominion of Canada and Newfoundland.*

Provinces.	1873.	1874.	1875.
Ontario	32.79	26.90	31.66
Quebec	38.64	36.64	42.32
New Brunswick	45.90	37.50	45.19
Nova Scotia	50.07	45.60	41.07
Prince Edward Island	41.38	40.39	43.46
Newfoundland	50.01	47.8	43.97
Manitoba	25.00	20.00	16.35

4. *Table showing the amount of Total Precipitation at Stations on Lake Ontario and the St. Lawrence, the Gulf of St. Lawrence, and the Atlantic Ocean.*

	1873.	1874.	1875.
Lake Ontario and the St. Lawrence.			
Toronto	31.59	24.34	29.73
Brockville	38.85	29.39	34.17
Montreal	42.76	39.03	39.69
Quebec	49.02	39.49	43.81
Gulf of St. Lawrence.			
Chatham	....	41.45	47.51
Dalhousie	....	....	43.42
Atlantic Ocean.			
Halifax	48.48	54.74	51.48
Sydney	....	51.26	44.23
Newfoundland.			
St. John's	54.72	64.13	45.47
Harbour Grace	45.52	50.64	39.20

In order to complete this outline sketch of the differences which exist between the total precipitation and the form in which it occurs near the seaboard and at inland stations, it is necessary to introduce a table showing the total precipitation and total fall of snow at certain stations where geographical position and elevation above the sea produce corresponding effects.

5. *Table showing the total Precipitation and total Snow-fall at certain selected Stations in the Dominion of Canada and Newfoundland.*

Stations.	Total Precipitation Inches.			Snow Fall. Inches.			Above the Sea, in feet.
	1873.	1874.	1875.	1873.	1874.	1875.	
Ontario.							
Woodstock.....	38.69	29.07	34.08	114	72	72	980
Kincardine.....	43.98	32.67	....	140	134	...	684
Stratford.....	40.06	33.33	37.90	102	114	136	1182
Quebec.							
Cape Rosier....	30.62	41.47	....	199	154	...	39
Quebec.....	49.02	39.49	43.81	237	150	182	293
Montreal.....	42.76	39.03	39.69	145	119	115	182
N. Brunswick.							
Bass River.....	....	34.66	40.87	183	119	138	70
Bathurst	36.75	29.67	36.53	144	87	93	4
N. Scotia.							
Sydney.....	....	51.26	44.23	142	126	138	27
Halifax.....	48.48	54.74	51.48	103	89	87	122
Newfoundland.							
St. John's.....	54.72	64 13	45.47	116	138	169	150
Harbour Grace *	45.52	50.64	39.20	16.42	12.25	137	60

* At Harbor Grace instead of the depth of snow its equivalent in water is given in 1873 and 1874. (Toronto Meteorological Report.)

From these tables it will be observed that ten and twelve feet of snow falling throughout the winter, year after year, is the rule at sea-board stations in the Maritime Provinces, and also at certain elevated stations in the interior of Ontario. If the climate and the surface of the country were such as to permit this large quantity of snow to drift in such a manner that considerable portions might remain in great accumulations throughout the year on the slopes of hills and mountains, as now occurs on the Labrador, some conception may be formed of the vast amount of glacial work which would be accomplished by the slow downward movements of the drifts.

But during the recognized submergence of the continent to the extent of several hundred feet, throwing the Labrador current in the direction of the valley of the St. Lawrence—always pressing westerly by the rotation of the earth—the necessary conditions of climate would be induced over a vast area. Wherever we find arctic and some sub-arctic shells in the drift, there too, on the neighbouring coasts, would snow drifts have accumulated

and effected their mechanical work of polishing the sides of ravines, moving rock masses, and assisting in a marked degree the general resulting denudation.

VIII.—Direction and Force of the Winds.

The constant high winds which prevail on the Labrador from west to east, coupled with the absence of forests on and near the exposed coast line, are the causes of the great drifts described in preceding paragraphs. The work of the drifts is determined by these winds to lie in a uniform direction, and their denuding effects are in general on the east or lea side of hills and mountain ranges, but not always so.

The following abstract shows the proportionate length of time that the winds from each point of the compass prevailed at Nain, Labrador, as indicated by the number of observations. (From Professor J. H. Coffin's Memoir on the "Winds of the Northern Hemisphere." Smithsonian Contributions to Knowledge, 1854, Vol. VI.)

Nain, Labrador.

Period one year.

North	160
N. E	82
East	77
S. E	7
South	6
S. W	12
West	180
N. W	140
Calm	2

The resultant of these observations is a direction very nearly parallel to the coast line and in the direction of the Labrador current.

Professor Coffin gives the general resultant direction of the winds at Nain for the period of eleven months as N. 25° 55′ W. with a note of enquiry (?), July being not recorded. The ratio of the progressive motion in the mean direction to the total distance travelled by the wind being as 50 to 100, showing a remarkable constancy of direction and force.

At St. John's, Newfoundland, this ratio is 18 to 100, and the mean direction S. 78° 4′ W. or not far removed from west and east, the number of years embraced in the observations being

four. The mean direction of the winds at Nain are therefore nearly at right angles to those of St. John's.

It is a legitimate conclusion from observed results that the mean direction of the wind during the winter months at any station will have an effect upon the distribution of snow drifts there. Hence where these drifts are permanent throughout the year, the mean direction of the wind determines also the aspect of the accumulations, and as a consequence the aspect of the denudation. Where the mean direction is from north to south, the southern slopes of hills will be precipitous, the northern sloping; where the mean direction is from east to west, the west exposures will be steep and abrupt, the eastern inclined. Hence the wind, acting through the instrumentality of snow, will ultimately exercise considerable influence in moulding and sculpturing the surface.

The *spruce trees* on the Labrador coast, which in some exposed localities have succeeded in obtaining a footing in a belt or series of narrow belts extending from north-west to south-east, furnish a remarkable illustration of the power and direction of the wind. They are rarely more than six feet long in the trunk before they begin to bend at right angles, and their branches and the upper half of the gnarled trunk grow horizontally, forming a very pretty level expanse of intricately interwoven branches, which are so compact as to leave the space beneath covered as it were with an impenetrable roof of green. One can creep underneath this miniature branch-woven forest, but to pass through it without cutting a road with an axe, or selecting a deviating course under the dwarfed trees from one open spot to another, is impracticable. One can get over it, and in some cases walk for a few yards on *the top of it*, but all attempts to get directly through it are unavailing. Peering and creeping underneath these tiny dwarfed forest roofs, one sees the leafless branches which underlie the surface sheet of green, all directed horizontally towards the south-east. The total height of most of the narrow "belt of woods" on the exposed coast did not exceed seven feet, but as soon as a sheltered cove or valley was reached, secure from the prevailing north-westerly winds, *and with a soil*, there the trees grew tall and straight, but such instances on and near the coast are rare, the surface is generally so denuded of soil by winds and drifts, that peat only and a few bushes, with berry bearing plants preserve a lodgment under the

ceaseless attacks of the north-westerly winds. The different methods in which winds affect the configuration of the surface, is discussed at great length in an article in Peterman's Mittheilungen by Dr. Frances Czerny of which an abstract appears in '*Nature*' (Jan. 11, 1877) entitled "The Action of the Winds in determining the form of the Earth."

IX.—Influence of Snow Drifts as a Geological Agent.

The description given by Mr. Lieber of angular masses of rock on Mount Bache, slowly moving down hill under the ceaseless influence of snow, offers an explanation of the sub-ærial denudation of large areas successively brought under the influence of snow drifts. Natural joints and cleavage in the first instance, greatly facilitate this operation, and those strata which are most subject to joints and weather easily, are the first to suffer from the effects of frost and yield to the influence of pressure. Although some of the strata of the Labrador series are exceedingly compact and tough yet others weather very easily, and are rapidly acted upon by frost, thus becoming worn and disintegrated by the pressure of slowly moving snow-banks on sloping surfaces. Dr. Hunt briefly describes the rocks of this series as follows: "The anorthosite rocks of the Labrador series present great variation in texture, being sometimes coarsely granitoid, and at other times finely granular. They not infrequently assume the banded structure of gneiss, lines of pyroxene, hypersthene, garnet, titanic iron ore or mica, marking the planes of stratification. Probably three-fourths of the anorthosites of this series in Canada, whether examined in place or in the boulders which abound in the St. Lawrence valley, consist of pure or nearly pure felspar rocks, in which the proportion of foreign minerals will not exceed five hundredths." *

Dr. Packard† describes the conical hills of Square Island, as weathering very easily, large masses being detached by frosts and readily crumbling to pieces. The great hypersthenic boulders at Porcupine Hill and on the shores of Lake Melville show a crumbling exterior.

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* On Norite or Labradorite Rock, by T. Sterry Hunt, LL.D., F.R.S.

† Observations on the Glacial Phenomena of Labrador and Maine. 1866.

I have shown elsewhere that land slides, in valleys cut through this series, (Explorations in the interior of the Labrador Peninsula; 1862) are numerous, and that the felspathic strata are those which first yield to frost, arising probably from cleavage, coupled with mechanical texture.

It may be mentioned here that on an Island about seven miles from Hopedale, and also in the vicinity of Hopedale, I found rocks which may belong to a formation separate from either the Upper or Lower Laurentian. Sufficient information regarding these beds has not yet been obtained on which to base an opinion. During the present summer opportunities may occur for securing more facts.

The existence of the Labrador series over a very wide extent of country between the St. Lawrence and the Northern Labrador, in the form of *Outliers* or detached areas surrounded by the Lower Laurentian rocks, and the presence of innumerable boulders show that it has been subjected to great but irregular wear. The thickness of the series is estimated at 10,000 feet. One may suppose that the process of denuding the Lower Laurentian of the Labrador series over a considerable part of the Labrador Peninsula, has been to a considerable extent effected through the instrumentality of Snow Drifts, which appear to have done very important work as a geological agent on the coast, and in earlier times in far lower latitudes, where the excavating work has been solely attributed to glaciers.

It will be seen that the argument here presented rests in the main upon the presence of an Arctic current. In all attempts to describe the origin of boulder-clays, the transportation of boulders, the scratchings on rocks in certain directions, apart from strictly glacial scratches, and the heaping up of vast accumulations of gravels, the presence of an Arctic current is always presupposed. Indeed, without such a cold current coming from the north or the south, drift work as we see it in very many instances, could scarcely be explained in the present state of our knowledge. We know that the slow subsidence of the continent would bring an enormous area under the prolonged influence of this current, which would be pressed to the westward by the rotation of the earth. The gradual rise of the land for a second time brings the successively rising surfaces under the influence not only of pan ice, but of snow drifts acting in the manner described, and like glaciers, continually retreating with the rise of

the land farther to the north. Hence I claim for SNOW DRIFTS an amount of denuding and polishing work which, when joined to that of PAN ICE, may assert for these simple agencies, now operating to an immense extent, an influence powerful enough to place them with denuding agents of the first class, among those different forms of ICE which assist in denuding the SURFACE.

NOTES UPON THE OCCURRENCE OF EOZOIC ROCKS IN THE SOUTH RIDING OF HASTINGS COUNTY, AND IN PRINCE EDWARD COUNTY, ONTARIO.

By D. F. H. WILKINS, B.A., Bac. App. Sci.,

Professor of Chemistry and Geology, Albert College, Belleville.

It is well known that the South Riding of Hastings County, and also Prince Edward County, are generally noted for a large development of Cambro-Silurian rock, particularly of Trenton limestone. Two well-defined exceptions to this are met with, however; one in Hastings County, near Shannonville, about six and a-half miles east of Belleville (by rail), and the other in Ameliasburgh Township, Prince Edward County, about six miles south-west of Belleville.

The former of these areas is an outcrop of crystalline rock, the most southern extremity of which is met with immediately opposite the Grand Trunk station of Shannonville, on the north side of the railroad, distant about three-quarters of a mile from the village. It occupies a great part of lot number five, in the first Concession of Tyendinaga Township, and is distant from the nearest outcrop of Laurentian rock, except the area referred to above, about twenty miles. It forms a ridge running north and south about two thousand and eighty feet, while its breadth varies from two hundred to one thousand feet, and its maximum height is about a hundred and ten feet. Like all other elevations in this and more northern latitudes, its northern face is steep and bluffish, and its greatest height occurs near the northern end, while it dies down gradually to the south.

It is composed of a gray and green slate conglomerate, weathering greenish-gray, and very much resembling the slate conglomerate of Lake Huron belonging to the Huronian system. The base of this rock is a schistose gray orthoclase with green hornblende and epidote, while the pebbles are of Laurentian gneiss, white and red micaceous and syenitic granite, syenite, felsite, dolerite, diorite, epidote, chlorite and quartz, these masses being generally rounded, particularly the gneissic pebbles, and very rarely angular, while in size some exceed a foot in diameter, and others are not over two or three inches. Excepting the rounded character of the fragments, its agreement with the breccia described on pp. 6 and 7 of Mr. Vennor's report on the Geology of Hastings County is very close. The measures are somewhat thin-bedded, some of the layers not exceeding one inch in thickness, and strike nearly uniformly N. 10° E. on an average, while they have a uniform dip of E. 10° S. < 69°. They are intersected by several quartz veins, having a general strike N. 40° E. one of which averages sixteen inches in breadth. Boulders and pebbles of the rock are of rare occurrence, and where found, *i. e.* only on its south-west side, constitute a small percentage of the erratics. No boulder of this character seems to be met with further south-west than three miles from the rock.

Although the line of junction with the Trenton limestone is everywhere concealed, yet according to Professor McCoun it was plainly visible many year ago before a quantity of limestone had been quarried for building purposes; the latter was then seen overlying unconformably the slate conglomerate of the ridge. On the west side the limestone forms several small folds with east and west axes and moderate dips of 15° to 20° to south and north. The summits of these anticlinals have been denuded and partly filled with soil, the breadth of surface denuded nowhere exceeding a hundred feet. As exposed on the railway track, the limestone is intersected by two sets of joints at right angles to each other, viz. one from north to south, and one from east to west. On the east side the limestone is not so well seen as on the west, and, where visible, occupies a much lower elevation; where seen, however, it has the same small corrugations as on the west side, and these extend in the same direction. The limestone has been most extensively denuded upon the northern and north-western sides of the ridge, where a bed of stratified sand and fine gravel at least fifteen feet thick is

exposed, the pebbles composing the gravel being in great part limestone from the underlying rocks. So far as known no ice groovings or scratches are visible on either the rock or the immediately surrounding limestone, although said to occur not further than half a mile to the south-east.

The second area of Eozoic rock occurs on a farm belonging formerly to one David Gibson, in lot number 70, Concession II, Ameliasburgh Township, Prince Edward County, and is hence known as "Gibson's Mountain," although, strictly speaking it should be called "Bell's Mountain" from the fact of its having been first studied by Professor J. T. Bell of Albert College. It is situated about six miles to the southwest of Belleville, and is distant from the "Picton road" about half a mile. The mass of rock occupies about fifteen acres, and rises about a hundred and fifteen feet above the plain, the greatest height occurring near its north end where it is bold and bluffish, while like the Shannonville outlier it dies gradually down to the south-west. It strikes north-east and south-west and is intersected by several small fissures; one, the most important nearly separating it into two masses. It presents the typical mammillated appearance of true Laurentian rock, and is similar in lithological aspect to this. It is composed principally of a flesh-red and dark-red orthoclase, the colour varying from nearly white to dark red, a small per centage of translucent quartz, a little dark green hornblende and a very little black mica, the two latter minerals being generally absent, and hence externally the rock is of a pale pink to dark red. Although several good sections are exposed—one in particular occurring where a downthrow of twelve feet has "slickensided" the rocks on one side and formed a small "valley of dislocation" with a strike of N. 23° E.—there is no distinct appearance of stratification in these. There are, on the contrary, several places where the rock becomes decidedly porphyritic, crystals of orthoclase of two inches in length having been met with there. Still its very close analogy with the more distinctly stratified rocks of the same lithological character in Labrador would cause one to describe it as a true Laurentian, very feldspathic, somewhat what porphyritic, coarse-grained, granitoid, syenitic gneiss. It is said to agree topographically with the "Red Hills" of Madoc Township, Hastings County, while it certainly appears to be almost identical with them lithologically, judging from the descriptions given by Prof. McCoun and other observers. Like

the Shannonville outlier, which it probably antedates, it possesses several veins of white quartz, two of the principal of which run, one in a direction N. 43° E. while the other intersects the downthrow referred to above with a strike N. 62° W. The latter is best seen upon the north-east face of the fault which is vertical, the opposite face being of gradual elevation from the lowest point and the vein being partly concealed by vegetation. Each of the veins is about sixteen to eighteen inches in width.

On the summit, whence a fine view can be obtained of the plain beneath, are several grooves and scratches and polishing caused by stones imbedded in ice, these being generally S. 67° W., or nearly parallel to the strike of the mountain, and also to the strike of numerous small cracks, while perpendicular to others, which seem to strike S. 62° E. In one place a most interesting groove runs along to the depth of two inches, the vertical face of a small eminence, this groove being continued with a strike S. 63° W. along the horizontal rock when again met with. Wherever a crack or fissure occurs transverse to the striation, it is noticeable that only the north-eastern face of the fissure has been acted on, the south-western always remaining intact. Boulders of the rock are very rare on its north-eastern side, but are rather common on the south-western edge. At various places on the south east side of the mountain, and at intervals over its surface the Trenton limestone is readily discernible, dipping S. 33° E. $< 23°$ to $< 26°$, while on its south-western face it dips S. W. $< 15°$, and in many places the line of junction between the two formations can be easily made out. On its north-west side occurs a bed of stratified gravel, apparently about ten feet in thickness, extending to the south-west side of the mountain.

In conclusion, it may be remarked that a hill about half a mile in length trending apparently north-east, rising to the same height as the Shannonville outlier but presenting an escarped appearance, and distant about one mile to the north-west of the latter, is composed, according to Prof. McCoun, who has minutely examined it, of the thick-bedded limestone, which cropping out on the Bay of Quinte at "Ox Point" about four miles to the East of Belleville, is met with near Stoco (or Stucco) Lake in Hungerford, and overlying the metamorphic rocks of Madoc and Huntingdon on Hog Lake in the latter township. Professor McCoun has also collected from the Shannonville outlier the

following plants which have been shewn by him to be peculiar to the metamorphic rocks of Central Canada:

Aspleninm ebeneum.
Carex longirostris.
Arabis hirsuta, var. Virginica.
Polygonum tenue.
Ceanothus ovalis.
Dicramum Muhlenbergii.
Dicramum spurium.

NEW FACTS RELATING TO EOZOON CANADENSE.

By J. W. Dawson, LL.D., F.R.S.

(*From the Proceedings of the American Association for the Advancement of Science, Buffalo Meeting, August*, 1876.)

At the last meeting of this Association, I had the pleasure of exhibiting some specimens of *Eozoon Canadense*, and of giving some oral explanations as to its nature and mode of occurrence. I now ask permission to mention a few additional facts which have been made known since the meeting at Detroit, and which still further contribute to our knowledge of the most ancient known fossil.

(1.) I would first beg leave to direct attention to the very interesting series of specimens now on exhibition in Philadelphia, in the collection of the Canadian Geological Survey; and which give a rare opportunity to study the various aspects of the fossil. In connection with Eozoon, I would also mention the remarkable mass of Graphite from Buckingham on the Ottawa, exhibited by the Dominion Plumbago Company of Canada. This mass is from one of the great beds of that mineral occurring in the Lower Laurentian, on a horizon not remote from that of Eozoon, and which in my judgment are really Laurentian coals, representing the vegetation of that period, as yet altogether unknown to us in its forms and structures.

(2.) A very interesting specimen, found last autumn by Messrs. Richardson and Weston, at Petite Nation, has enabled

me to delineate, in a recent paper, the inverted conical form of a perfect small specimen of Eozoon, and also to show that the acervuline chambers on its upper surface are precisely similar to those small aggregations of spherical chambers resembling *Globigerinæ*, and to which I have given the name *Archæospherinæ*; so that these may not improbably be loose chambers or germs of Eozoon.

(3.) Mr. W. J. Morris of Perth, Ontario, has in the past summer found abundant specimens *in situ* of Eozoon mineralized with Loganite, in the original locality at Burgess. These specimens show that the Burgess variety is on the whole thicker and more continuous in its sarcode chambers, and less developed as to the separating walls than the Grenville and Petite Nation specimens. These new specimens from Burgess have also enabled me for the first time to detect in their dolomitised walls traces of the canal system, into which, however, the Loganite does not penetrate. In some in which the dolomite is mixed with calcite, there is also an extremely minute granular structure, which I believe to indicate an originally porous character of the cell-wall, of which only obscure indications exist in other specimens.

(4.) Mr. G. F. Matthew has sent to me from the Laurentian of Lily Lake, near St. John, New Brunswick, specimens of a dolomitic limestone containing fragments of the skeleton of Eozoon, showing the canal system. This is the first recognition of this fossil in the Laurentian of New Brunswick. A notice of the fact has appeared or will shortly appear in "Silliman's Journal."

(5.) Recent explorations by Mr. Vennor of the Gelogical Survey have thrown further light on the precise geological horizon of Eozoon in the great Laurentian system. In Sir William Logan's original sections on the East side of the Ottawa, the lowest rock represented is a great thickness of orthoclase gneiss, corresponding probably to the fundamental or Bogian gneiss of the Scandinavian and Bavarian geologists. Above this is a very thick limestone, that of Trembling Lake, which has afforded no fossils. Next is another vast thickness of gneissic beds. Then comes a second limestone, also non-fossiliferous as yet, that of Green Lake. Then another gneissic series and a third limestone, that of Grenville, which is the special resting place of Eozoon, and is also associated with beds rich in graphite and in calcic phosphate. Still higher is a fourth limestone, and then the

Upper Laurentian. Mr. Vennor's observations relate to a region about eighty miles distant, on the west side of the Ottawa, and remarkable for its rich deposits of apatite and graphite, though affording Eozoon only in a few places, and in these not precisely in the same state of mineralization as at Petite Nation and Grenville. In this region Mr. Vennor has worked out a series corresponding in its main features with that ascertained by Logan, and it now appears that in both series Eozoon is apparently confined to one horizon, and that in this it is associated with the more important deposits of graphite and apatite. It is true that in the districts explored by Mr. Vennor there are some groups of strata of uncertain age, and which may be upper Laurentian or even Huronian; but the main accordance above stated seems to be certain. It would thus appear that Eozoon and those deposits of graphite and apatite which are probably of organic origin, are characteristic of one great zone of the Lower Laurentian.

(6) The abundant phosphates occurring in the Lower Laurentian, and as already stated in irregularly stratified beds, and associated with graphite and Eozoon, naturally raise the question whether they are of organic accumulation. The apatite of the Lower Laurentian has indeed as yet afforded no organic structure. Some light may however be thrown on its origin by the analogy of later deposits of similar character; and I have endeavored, in a paper recently read before the Geological Society of London, to show that the calcic phosphate contained in the Cambrian and Silurian rocks of Canada presents in its mode of occurrence points of similarity to that of the Laurentian; while the prevalence of low forms of life, as *Lingulæ*, *Trilobites* and *Hyolithes*, having much calcic phosphates in their skeletons, in the Primordial seas, and the consequent accumulation of beds rich in phosphatic concretions and coprolites, points to the possibility of similar conditions in the earlier Laurentian. I may also here refer, as corroborative of this view, to the recently published researches of Hicks and others on the Silurian Phosphates of Wales.

(7.) The objections to the animal nature of Eozoon recently promulgated by Otto Hahn, and which have been answered in detail by Dr. Carpenter and myself, have directed attention anew to the geological relations of serpentine; and though I must protest against the idea prevailing in some quarters, that there is any necessary connection between this mineral and Eozoon,

yet as serpentine exists in connection with many specimens of this fossil, it is time that geologists were warned against the extravagant ideas of pseudomorphism which have been promulgated in connection with it. I have, therefore, been engaged in the present summer in re-examining large series of specimens of serpentines associated with organic remains, and have visited some of the Canadian localities of such serpentines, and have studied their geological relations. I hope to show, when these researches are complete, that microscopical and palæontological evidence completely vindicates the theory of aqueous deposition of serpentine as maintained by Dr. T. Sterry Hunt, and shows that this mineral, like glauconite and similar silicates, may fill the pores and cavities of fossils, without in any way destroying their forms or structures. I have examples of Silurian corals and other fossils mineralized with true serpentine, precisely like Eozoon in the Laurentian. Further it can be shown that the Lower Silurian serpentines of Canada, alike in their interstratification with fossiliferous limestones, and in their passage into limestone, dolomite and even red slates, conform in a striking manner to the known laws of deposition of hydrous silicates in the modern oceans. Whatever opinions may be held as to the metamorphic origin of certain serpentines, or as to the mode of formation of serpentine veins, the facts I already possess are amply sufficient to show that such theories have no application to the ordinary serpentines found in beds associated with fossiliferous rocks.

(8.) I may add that I hold Gümbel's elaborate exposition of the foraminiferal nature of *Receptaculites*, in the Transactions of the Royal Bavarian Academy, and the announcement by Prof. Karl Moebius of a recent sessile Foraminifer from the Mauritius, not very remote from Eozoon in its general mode of growth, to be important contributions towards the history of this oldest fossil; whose investigation, as will be seen from the above notes, is by no means fully worked out.

NATURAL HISTORY SOCIETY.

PROCEEDINGS FOR THE SESSION 1876–77.

FIELD DAY AT BELŒIL.

On Saturday, June 10th, 1876, the Society held a field-meeting at Belœil mountain, to which, as on former occasions, the public was invited. A special train was engaged, and a party of between eighty and ninety friends of the Society left the Bonaventure station at 9.30 a.m. and reached St. Hilaire at 11 o'clock. From thence the excursionists leisurely proceeded to the lake near the Iroquois house, some on foot, others in various kinds of vehicles. On their arrival at this point about noon, Dr. J. Baker Edwards explained the programme of proceedings for the day, and read a letter from Bruce Campbell, Esq., in which that gentleman regretted that he was not able to be present at the meeting, but welcomed the visitors to the grounds, and gave some historical particulars about the mountain. An interval of an hour having been allowed for luncheon, at the expiration of that time the ascent of the mountain was commenced, and when the summit was gained, the President gave the following brief explanation of the geological features of the district.

Principal Dawson said that it devolved on him, as President of the Society, to address a few words to the friends who had honoured the excursion with their presence. He regretted the unavoidable absence of some gentlemen who might have spoken on this occasion; and expressed the thanks of the Society to Mr. Campbell, the Seignior, both for the use of his beautiful grounds and for the interesting historical information which he had been good enough to communicate, and which had been read to those present. The geology of Belœil, and the country visible from it, had been several times, on occasions of this kind, ably expounded on this breezy summit, so unfavourable in some respects for a geological lecture, but so inspiring in the wide and beautiful view which it commands. He would refer very shortly to the fact that Belœil mountain stands, with some other hills, in the midst of an undisturbed Silurian plain, and that the view from

it is bounded on the north by those oldest foldings of the crust of the earth which constitute the Laurentian hills, and on the south by the somewhat less ancient wrinklings which have produced the hills of the Eastern Townships and the Green Mountains. The mountain itself is an igneous or volcanic mass, rising through rocks of the Hudson River or Cincinnati group, which are seen on its flanks, and consisting of dense crystalline material such as that which forms the deeper and hidden part of modern volcanoes, but which has here been laid bare by the removal of the lighter scoriaceous and tufaceous matter which once covered it. The date of the activity of these Lower Canadian volcanoes is far back in geological time. They were probably cooled out before the close of the Silurian age, and since that time they have been subjected to the denuding action of the atmosphere and its waters, and more than once to the waves and currents of the ocean. The last known residuum of the sea in the Lower Canadian plain is evidenced by the clays and sands of Pleistocene date, and holding marine shells, scattered over its surface; and also by the occurrence on this mountain, at a height of 1100 feet above the sea, of water-borne Laurentian boulders from the Laurentide hills to the north, specimens of which may be collected on the path leading to the summit. Any one viewing from the present standpoint the wide and low valley of the St. Lawrence and the blue Laurentian hills, at least fifty miles distant, from which these stones must have been borne (and they probably came from much greater distances than the nearest margin of the Laurentian), must be convinced that no other means than those of floatage by water could have carried them so far. We are thus carried back to that phase of the so-called glacial period when Belœil was a mere rock in the sea, and fields and bergs of ice were drifting against it, borne on by the northeasterly Arctic currents, from the distant Laurentian hills, then little elevated above the sea, and probably for the most part snow-clad.

We are reminded by these geological facts of the treasures that exist in the rocks and soils which are overlooked from this summit,—the iron, lead, plumbago and phosphates of the Laurentian range; the vast expanse of fertile soil in those fields that stretch almost interminably over the plain of the St. Lawrence; the copper, the gold, the antimony, the iron, the slates, the marbles of the southern hills. This is a rich inheritance of

wealth, but yet utilised only in a small degree compared with its capabilities. To receive the full benefit of these great treasures which Providence has placed within our reach, we need more practical science. We have seen too much of the neglect and loss of valuable minerals and of the deterioration and waste of soils, of the squandering of money on worthless objects, of the neglect of science and its votaries by our public men and our business men. The ignorance of the masses of our population, the want of appreciation of the value of science on the part of capitalists, the paltry sums granted by our government for scientific research, the almost entire want of encouragement and support to our scientific schools, these are features of Lower Canadian life saddening to any man who wishes well to his country, discouraging to those who have struggled for better things. Let us hope that a brighter time is coming, and that even the little twinkling light which our Natural History Society has sustained amidst the darkness, may be revived and made to shine more brightly in the time to come.

Although in the morning the clouds looked threatening, the day on the whole was bright and sunny, with the exception of one or two light showers which fell in the afternoon. A list of the plants met with at this locality has already been published in these pages, and few, if any, additional species were collected on this occasion. The entomologists of the party were, however, more successful, as the following list of insects taken or observed during the day, kindly prepared by Mr. F. B. Caulfield, will testify:

Coleoptera.

Cicindela purpurea Oliv.	One specimen.
" sexguttata Fabr.	do.
Pterostichus lucublandus Say.	Two specimens.
Harpalus Pennsylvanicus Degen.	Several taken.
" ——? undetermined.	Three specimens.
Silpha peltata Cates.	One specimen.
Leistotrophus cingulatus Grav.	do.
Aphodius fossor Fabr.	do.
Geotrupes excrementi Say.	do.
Dichelonycha elongatula Fitch.	Several.
Ancylocheira maculiventris Say.	One specimen.
Telephoens Carolinus Fabr.	Several.
Melandrya striata Say.	One specimen.
Meloe augusticollis? Say.	do.

Asclera ruficollis? Say. Several.
" —— ? undetermined. Several.
Callidium antennatum Newm. One specimen.
Galeruca —— ? undetermined. do.
Labidomera trimaculata Fabr. Several.
Calligrapha Bigsbyana Kirby. One specimen.
Coccinella —— ? A beautiful species, not represented in any Canadian collection that Mr. Caulfield has seen.

Lepidoptera.

Papilio Turnus Linn. Tiger swallow-tail. Several seen.
Pieris rapae Linn. The cabbage white. Two seen.
" oleracea Harris. Grey veined white. One taken.
Colias Philodice Fabr. Clouded sulphur. Several seen.
Lycaena Lucia Kirby. Spring azure. One taken.
Vanessa Antiopa Linn. Camberwell beauty. One seen.
Nisoniades brizo. The brizo skipper. One taken.
Atrytone zabulon Boisd. Tawny skipper. do.
Sesia uniformis Grote. Humming-bird moth. do.
Deilephila Chamaenerii Harris. Lilac hawk moth. do.
Euprepia Americana Harris. American tiger moth.
Two caterpillars taken nearly full grown.
Clisiocampa Americana Harris. American tent caterpillar.
" sylvatica. Forest tent caterpillar.
Caterpillars of both of these moths were seen during the day.
Ctenucha Virginica Charp.
A cocoon of this moth was found on a fence by the road side.
Cucullia Intermedia Speyer. One specimen taken.
Lozogramma difluaria. do.
Drasteria erecthea Guen. do.
Cidaria —— ? undetermined. do.
Two undetermined species.

Orthoptera.

Gryllus neglectus Scudder. Common field cricket.
One specimen taken, several heard during the day.
Tragocephala infuscata Harris. Dusky locust.
One specimen taken, several seen.

Neuroptera.

Panorpa rufescens Rambur. The rusty scorpion fly.
Two specimens taken, not hitherto recorded from Canada, so far as Mr. Caulfield is aware.

After spending some time in gazing on the beautiful landscape spread out beneath them, and in examining the various objects of interest to be met with at this elevation, the party returned to the lake, and after wandering round its margin for an hour or

more, made its way back to the St. Hilaire Station at 4.30 p.m., and reached town a little after six o'clock.

The first prize, for the largest number of named species of flowering plants, was awarded to Mr. J. B. Goode, but no other prizes were given, as the collections submitted for competition were not deemed to be of sufficient merit.

MONTHLY AND OTHER MEETINGS.

Special Meeting of the Society, held June 26th, 1876.

The meeting was called for the purpose of considering the desirability of procuring a suitable memorial of the late Mr. E. Billings.

On motion of Mr. G. L. Marler, seconded by Mr. J. H. Joseph, it was resolved:

"That on the occasion of the decease of Elkanah Billings, F.G.S., one of the Vice Presidents of the Society, and for many years one of its most eminent members, the founder of the *Canadian Naturalist and Geologist*, and above all the careful and accurate describer of the Palæozoic Fossils of Canada, it becomes this Society to testify its sense of the great scientific services of the deceased, and its high estimate of the importance of palæontological research to the practical and scientific exploration of this Dominion. This meeting would therefore record its appreciation of the life-long labours of Mr. Billings in the cause of science, and its sorrow for his removal from among us, and would convey to his widow and other relatives its sympathy with them in their bereavement."

On motion of Mr. J. F. Whiteaves, seconded by Mr. Christian Hoffman, it was further resolved:

"That a Committee of the Society, to consist of the President, the Rev. Dr. DeSola, Rev. Canon Baldwin, Drs. B. J. Harrington, John Bell, and the mover, be appointed to take such steps as may seem to them desirable to provide a suitable memorial to the late Mr. Billings."

The opinion of those present was in favour of obtaining an oil painting of the deceased, to be hung in the Society's rooms, and Mr. Whiteaves with Dr. John Bell were requested to inquire if there were any existing portraits from which a copy might be made.

It was then moved by Mr. J. H. Joseph, seconded by Mr. C. Robb, and resolved:

"That the same Committee be empowered to take steps for procuring a portrait of the late Sir W. E. Logan for the Society's rooms."

1st Monthly Meeting, held October 30th, 1876.

The members of the Lecture and Conversazione Committee of last year (viz. Rev. Dr. DeSola, Dr. J. Baker Edwards, Dr. Harrington, Rev. Canon Baldwin, and Prof. Darey) were re-elected, and the name of Dr. W. Osler was added.

Principal Dawson then made a communication "On some features of the Geology of the Intercolonial Railway."

Some remarks on this topic were made by Mr. A. R. C. Selwyn, who also moved a vote of thanks to Principal Dawson for his interesting exposition of the subject.

2nd Monthly Meeting, held November 27th, 1876.

Dr. Buller and Dr. Alloway were elected resident members, Mrs. E. K. Greene and Miss Atwater, associates, and Albert J. Hill, a corresponding member of the Society.

An obituary notice of the late Mr. E. Billings was read by the Recording Secretary. This will be found at the commencement of the present number.

3rd Monthly Meeting, held January 29th, 1877.

Messrs. G. S. Wilson, James Walker, N. R. Mudge, and Humphry were elected resident members.

Dr. W. Osler then read a paper "On the Fresh Water Polyzoa of Canada," illustrating the subject by diagams and microscopical preparations.

After some remarks by the President, the meeting was adjourned.

4th Monthly Meeting, held February 26th, 1877.

It was resolved "that the name of Mr. J. Fraser Torrance be associated with that of Dr. Harrington in the editorial supervision of the *Naturalist*."

A collection of coleoptera from the Upper Peace River country, collected by Mr. A. R. C. Selwyn and Prof. Macoun in 1875, and named by Dr. Leconte, was exhibited and placed by Mr. Selwyn on deposit in the museum.

Dr. Donald Baynes and Mr. P. S. Ross were elected members of the Society.

A paper by Prof. H. Y. Hind, M.A., "on some Geological Features of the Northern Labrador coast," was then read by the Rec. Secretary. This will be found on page 262.

A discussion ensued, in which the President, Mr. Selwyn, and other members took part.

5th Monthly Meeting, held March 26th, 1877.

Mr. W. Kennedy was elected a member of the Society.

A number of photographs of inscriptions from Easter Island, of the natives, &c., of the same locality, were presented by the President on behalf of D. Robertson, Esq., and exhibited at the meeting.

A paper entitled "Notes on Elevation of the Land in British Columbia," was then read by Mr. G. M. Dawson.

Principal Dawson made a communication explanatory of the photographs of inscriptions, &c., from Easter Island, previously mentioned.

A paper from a gentleman resident in India, being a series of miscellaneous Natural History notes, was also read by the Rec. Secretary.

The proceedings were closed by the passing of a vote of thanks to thd authors of the papers read.

6th Monthly Meeting, held April 30th, 1877.

Mr. J. L. Macpherson was elected a resident member, and Count de Premio Real (Vice Consul for Spain at Quebec), a corresponding member of the Society.

The Rec. Secretary then read a paper by Dr. P. P. Carpenter "on the proposed alterations in the rules of the British Association for Zoological nomenclature."

Comments on some of the points raised in this communication were made by the President, the Rec. Secretary, and others, but the views advocated by Dr. Carpenter were on the whole approved by the meeting.

Dr. Harrington presented the second part of Prof. Hind's paper on the Geology of the N. E. coast of Labrador, which was laid on the table and taken as read.

SOMMERVILLE LECTURES.

The free public lectures of the Sommerville course were duly delivered during the months of January and February, 1877, to good audiences. The following is a list of the titles of the lectures, with the dates at which they were delivered, and the names of the authors.

1. Jan. 11th, 1877. The Andes of Ecuador.
   By Thomas Macfarlane, Esq.
2. Jan. 25th, 1877. Cuvier and his Contemporary Naturalists.
   By Prof. P. J. Darey, M.A., B.C.L.
3. Feb. 1st, 1877. Two years on the Amazon and Madeira rivers, Brazil.
   By Donald Baynes, A.M., M.D.
4. Feb. 8th, 1877. A visit to Sarawak, Borneo.
   By J. Fraser Torrance, A.B., B.A.Sc.
5. Feb. 15th, 1877. A visit to British Columbia.
   By G. M. Dawson, M.E., F.G.S.
6. Feb. 22nd, 1877. The Centennial Exhibition, Philadelphia.
   By S. C. Stephenson, M.A., Secretary to the Centennial Commission.

ANNUAL MEETING.

The annual meeting was held on the 18th of May, 1877.

The minutes of the last annual meeting having been read, the annual address was delivered by the President, Principal Dawson, as follows:

ANNUAL ADDRESS.

In closing another Session of this Society, we naturally turn to the work of the past year, and in this address it is more especially our scientific labours that claim attention. What have we done in the past year for the advancement of science, and for the credit of our country as one of the civilized nations of the world? I would not underrate what we have accomplished for the popular diffusion of knowledge, by means of our museum, our excursions and our popular lectures, but the original investigations which we have given to the world constitute our best title to regard as a scientific association.

In the course of the winter nine original communications have been laid before thie Society; and of these the greater number have appeared or will appear in our Journal. Of these commu-

nications two; namely, that on Inscriptions from Easter Island presented by Mr. D. Robertson, and Notes on Animals of India, did not refer to the natural history of this country. With respect to the former, however, I may say that it has a connection with America in the circumstance that so many indications point to a migration of civilized or semi-civilized men into America by way of the Pacific, and to the probability that Easter Island was one of the stations in this migration. Mr. Hyde Clarke and Dr. Wilson have both directed attention to this subject, and have shown that in languages and physical features there are links of connection between the Polynesian and the Peruvian races, and that the ruins of large stone buildings found in so many of the Polynesian Islands, as well as the arts practised in those islands, point to similar conclusions. The possession of a sort of picture writing for the keeping of family and tribal records in Easter Island, and the not very remote resemblance of this to some familiar American contrivances of the same kind, furnishes an additional link of connection. On the often disputed question of the source or sources of the aboriginal American population, it now seems to be the settled conclusion of archaeology that we have good evidence of prehistoric migrations of man into America by Behring's Straits from Northern Asia; by the Pacific Islands from Southern Asia; and by the Equatorial Atlantic, by way of the Canaries and West India Islands. To these we have to add the probability of Chinese and Japanese ships having at various times been drifted upon the Pacific coast, and the discovery of Greenland and part of the mainland of America by the Norsemen in the tenth century. Thus there seems to be not one way merely but several in which America may have received its early population, and by which we may account for the native races of America with their languages and customs merely as derivatives from the old world, and without supposing these tribes to be true Autochthones.

Two very interesting communications of a geological character were those of Prof. Hind on the Geology of Labrador, and of Mr. G. M. Dawson on Recent Elevations and Subsidences of the Land in British Columbia. Remote though these regions are from each other, they present some remarkable points of similarity, especially in relation to their more recent geological history. In both we have the evidence of the great glacial age. In both the surface glaciation and transport of boulders seem to

have been caused by the joint or successive action of water-borne ice, and glaciers. In both there are the most remarkable evidences of submergence to a great depth in the Post-pliocene age. It is a remarkable illustration of the vastness of the geological changes which have occurred in comparatively modern times, that we should find on the mountains of the Pacific Coast and those of the North Atlantic seaboard the indications of a common submergence, and this of very great amount. Such vicissitudes are not to be accounted for by merely local causes, but by grand agencies effecting at once a whole hemisphere or the whole earth.

In British Columbia there seems to be good evidence of the submergence of the land to such an extent that sea margins occur 5270 feet above the level of the sea, and at various elevations between this and the present sea level. In the Rocky Mountains Mr. Dawson had previously measured the height of similar terraces 4400 feet above the sea. While those great depressions occurred in the Post-pliocene period, there is evidence to show that in the preceding Pliocene age the land in British Columbia may have been 900 feet higher than at present. On the other hand, in modern times the coast would seem to have been going down at a rate in some cases of as much as ten to fifteen feet in a century; while there are Indian traditions of sudden waves overflowing the land, and perhaps occasioned by earthquake movements. With reference to these modern changes, it should be observed that British Columbia forms a part of that great band of volcanic and seismic activity which extends along the west coast of America, and which presents in our own time and in the more recent geological periods, evidences of agencies which have long slumbered on the eastern margin of the continent.

On our own side of America, the numerous terraces so well developed on the Lower St. Lawrence, mark the stages of recession of the Post-pliocene ocean. Mr. Richardson informs me that he has found one of these terraces on the west coast of Newfoundland, at a height of 1225 feet above the sea. On Belœil Mountain, in our own neighbourhood, we find travelled Laurentian stones which must have been water-borne, at a height of nearly 1200 feet, and if the travelled stones found by Prof. Hitchcock on Mount Washington have been deposited by floating ice, then the highest summits of our mountains must have been under water at the time of the greatest Post-pliocene submer-

gence. Mr. Milne Home has recently directed attention to many facts of similar import which are being accumulated in Great Britain and in Norway. Geologists are thus beginning to realize the evidence of a prevalence of the sea over the Northern hemisphere in the most recent of the geological periods; which at one time they would have regarded with the utmost scepticism.

While noticing these papers, I would also direct attention to the evidence which they afford as to the action of sea-borne ice as distinguished from that of glaciers; and in connection with this it is important to note the influence attributed to floating pack ice and "pan ice" by the officers of the late Arctic expedition, as well as by Prof. Hind and by Prof. Milne in recent papers in the Geological Magazine. On the other hand the observations of Hellond on the glaciers of Greenland, published in the Geological Magazine, state the interesting fact that one of the great glaciers of that country flows seaward at the surprising rate of 20 metres in a day, and gives off a vast abundance of bergs, more or less laden with earthy matter and boulders. A fact like this helps us to understand the gigantic furrows ploughed by some of the old local glaciers of the Laurentian hills, and of which the sluggish glaciers of the modern Alps afford no adequate explanation.

All these new facts tend to strengthen the conclusion that general submergence and the action of floating ice and of local glaciers afford the causes at work in the so-called glacial age.

In the department of Zoology we have reason to congratulate ourselves on the communication of Dr. Osler on the Fresh-water Polyzoa of Canada. These remarkable and interesting animals, though abundant in our canals and ponds and slower streams, have as yet received little attention. The contribution of Dr. Osler brought under our notice several species; some of them forming communities of considerable size, and all of them of very great interest and beauty.

Our attention was called by Dr. Carpenter to the subject of Zoological nomenclature, in connection with a circular issued by Mr. Dalle on behalf of the American Association for the Advancement of Science. With the replies prepared by Dr. Carpenter most of us I think in the main agree; and while we regard as very reprehensible many of the eccentricities of genus-makers and species-makers, more concerned to gain credit to themselves than to advance the interests of science, we equally reprobate the

over-scrupulous antiquarianism which would revive uncertain and forgotten names to the exclusion of those sanctioned by long use. There is perhaps little hope that these evils can be wholly remedied in the present state of science, when there is in this respect no king in Israel, and every man does what is right in his own eyes. We believe however that the old rules sanctioned by the British Association, with a moderate amount of self-abnegation and common sense, will be sufficient to secure all that is really necessary.

The lamented death of Mr. Billings is a heavy blow to this Society, as well as to the cause of science in Canada; and one of our meetings was appropriately occupied with an obituary notice by his successor, Mr. Whiteaves. It is not necessary for me to refer to the details contained in that notice. I may remark however that Mr. Billings may be considered as the creator of Canadian Palæontology, in so far as the Invertebrate fossils of the Palæozoic rocks are concerned. This department he built up from its foundations, and built so extensively and so well, that it will be long before his work can be hidden from view by any additions to be made by his successors. As a worker he was painstaking and cautious rather than rapid, and his results were always regarded with respect and confidence by those engaged in similar pursuits elsewhere. He was not a mere describer of species, but a geologist of sound and broad views, and his earlier works show a power of lucid and popular presentation of his subject which it is perhaps to be regretted he did not follow up in his later years. One of his greatest failings was a certain shrinking from publicity, which rendered him indisposed to take a prominent position even in the work of our own Society, and still more tended to prevent him from entering into any presentation of his favourite studies to the general public in any other form than that of official reports and scientific papers. Such men as Mr. Billings are produced in small numbers in any country, and it may be long before Canada possesses as one of her own sons a second Billings. It is however a remarkable coincidence that such a man should have been preparing himself to second the work of Sir William Logan just at the time when Palæontological work had become a prime necessity for the Canadian Survey.

I have reserved to the last some remarks connected with the subject of my own paper on the Geology of the Intercolonial

Railway, and which subject I desire here to refer to in a somewhat broad and discursive manner, demanded I think by the present condition of science and the industrial arts in this country. I would in this connection desire to direct your attention to the immense importance of that great public work, and to the effects which would flow from a further extension of similar enterprise in the west. I can remember a time when the isolation of the Maritime provinces from Canada proper was almost absolute. There was a nearly impassable wilderness between, and no steamers on the waters, and the few whom business or adventure caused to travel from Halifax or St. John to Quebec or Montreal, had to undertake a costly and circuitous journey through the United States, or to submit to almost interminable staging through a wilderness, or to the delays of some sailing craft on the St. Lawrence. In later times steamboats have supplied a less tedious mode of communication, and now we see placards informing us that the Intercolonial carries passengers from Quebec to Halifax in twenty-six hours. But it has done more than this. The traveller may now see the coal of Nova Scotia travelling upward to Quebec, and the fresh fish of the Atlantic coast abundantly supplied in our markets, while the agricultural products of the interior travel seawards in return. This is however but the beginning of a great change. A delegation of coal owners was in Ottawa last month endeavouring to attract the attention of members of the Legislature to the fact that Ontario might be cheaply supplied with coal from Nova Scotia in return for her farm products. The representation led to no immediate practical results, but it foreshadows a great future change. Living as we do on the borders of that great nation without any name, except that of America, which does not belong to it, and which builds an almost impassable wall of commercial restriction along its frontier, we cannot long endure the one-sided exchange of commodities which takes place at present so much to our disadvantage. The Nova Scotian cannot buy flour and manufactured goods from a people who refuse to take his coal and iron in exchange; and the Ontarian or Quebecker cannot afford to have the commercial connection with the mother country severed in favour of a nation which will not take the products of our fields, our forests, our mines or our granaries in exchange. We shall have in self-defence to cultivate our own internal trade, and even if we must bring the

products of the Pacific and Atlantic Coasts across a whole continent to meet each other, this will be cheaper in the end than to sacrifice our own interests and those of the empire to the Chinese policy of our neighbours in the South.

The diversities of products in countries depends much on differences in latitude, but there are also diversities depending on longitude, and, fortunately our country possesses these in no small degree. On our Atlantic coast we have rich fisheries and minerals not possessed by the interior regions. In these last, through all the great regions extending from Quebec to the Rocky Mountains, we have vast breadths of fertile soil besides many of the elements of mineral wealth, and varied kinds of manufactures are growing up both on the coast and inland. What is to hinder a direct exchange of commodities within ourselves instead of an indirect exchange under the most serious disadvantages with the United States. Further, such direct exchange would increase our trade with Great Britain and the West Indies, and bind together the somewhat divergent sections of our own population. The opening up of railway communication across the great western plain might do for us what a similar process has done for New York. But from a railway terminus on the Pacific shore we could stretch our commercial relations over that great ocean, and bring all the treasures of the Orient to enrich our markets. Further, in establishing communication with British Columbia, we are not merely establishing a landing place on the Pacific, though this would be an inestimable advantage. British Columbia is in the mining point of view, one of the richest portions of the earth's surface. It is of more value acre for acre than any portion of the Eastern States or of Canada proper. In an appendix attached to a recent report on the Pacific railway, Mr. G. M. Dawson has collected some details as to the mineral wealth of this region. He mentions gold-fields yielding now more than a million and a half of dollars annually. In eighteen years British Columbia with only 10,000 inhabitants has exported gold to the amount of 40,000,000 of dollars; and it is no exaggeration to say that with a larger population and better means of conveyance this yield might be increased twenty fold.

Coal exists on Vancouver's Island and the neighbouring mainland in inexhaustible abundance, and of excellent quality, and

represents the sole supplies of that mineral on the Pacific coast of North America. British Columbia might supply the whole Pacific coast and a vast interior region, and might produce many millions of tons annually.

Iron, silver and copper are known to exist in productive quantities, and there is reason to believe that mercury, lead, and platinum might be added.

In short, British Columbia posssesses all that mineral wealth which has enriched California and the States adjoining it; and the opening up of communication between it and other parts of the Dominion would be the beginning of a series of events that would build up great and wealthy cities and populous seats of industry in a region now scarcely inhabited, and cut off from direct intercourse with the other provinces politically connected with it.

What the Intercolonial has begun to do for our relations with the Atlantic provinces, the Canada Pacific must do for our relations with the Pacific province; and if I could present before you in a prophetic picture all that would follow from the establishment of such a connection, and the trade of the great sea and lands beyond, which might flow through our country, you as citizens of a commercial city, as well as in the capacity of votaries of science and scientific art, would at once say that at almost any sacrifice this great work should be executed. The difficulties in the way are undoubtedly great—so great that this generation of Canadians should scarcely be called upon to overcome them unaided, but they are probably not insurmountable, and the mode of meeting them is certainly at present the greatest public problem that our statesmen have to solve. It is further undoubtedly the duty of those whose scientific studies show them the grandeur of this great question and the nature of the practical results of its solution, to aid in every way that they can the progress towards an unobstructed highway through our territory from the Atlantic to the Pacific.

If it is in our power thus to bring together the resources of the whole breadth of the Continent, we may hope to consolidate our connection with the Mother Country by making ourselves indispensable to her interests, to relieve ourselves from the galling commercial yoke laid upon us by our neighbors, to provide homes and work for the surplus population of our older provinces, to build up the wealth of great trading centres, and to render

vast and naturally wealthy regions productive of subsistence for millions of men.

When I look forward to the future of this country and base my anticipations, not on the merely human elements of to-day, but on the geologic treasures laid up in past ages, I see the Dominion of Canada with a population as great as that of the United States, and with some of the greatest and wealthiest cities of this continent in Nova Scotia and British Columbia. Geologists are not merely prophets of the past, they know something of the future as well. It might perhaps be well if we could inoculate our statesmen with a healthy belief in the geological future of Canada, or even with some faint idea of the billions of dollars of accessible treasures that lie beneath the soil of British Columbia and Nova Scotia. We might then see them put forth some effort to realize this El Dorado within the time of those now living, rather than contentedly allow it to wait the action of men wiser and more energetic than ourselves.

Of the future of our own Society I shall say little. Much must depend on a judicious selection of officers, much on the liberality which the public may extend to us, much on the earnest efforts which our working members may put forth, and this not merely in the pursuit of new truths, but in cultivating in others a desire for that knowledge which we know from our own experience to be in itself one of the richest treasures which the world affords.

It is a matter of deep regret to us on this occasion that a recent Act of the Dominion Parliament renders it possible that the Geological Survey of Canada, which has since its commencement had its domicile in this city as the centre of commerce and practical science in the Dominion, may within one or two years be removed to Ottawa. That this, should it be carried into effect, would be a serious loss to this Society, the large number of papers and lectures contributed by members of the Survey, and the active part they have taken in the management of its affairs as officers and members testify. The removal of the Survey would also have its effect on the University, and on the interests of the numerous students who resort to this city for education, as well as on those of gentlemen connected with the numerous mining and similar enterprises which have their centre here. Nor would such removal be without injurious influence on the Survey itself. This Society was the first public body to urge on the

Government the undertaking of a scientific survey. The Natural History Society, the University and the citizens generally, have always supported the interests and aided the work of the Survey, and have in many ways promoted its efficiency. Nor can an institution possessing a Museum and Labratories which are the growth of so many years, be hastily removed without serious loss, only to be repaired by renewed effort and the lapse of time.

But to my mind these local considerations are overborne by the change in the constitution of the Survey which has been made, rather, I fear, in the spirit of a narrow bureaucracy than of an enlightened regard for science. Hitherto the Survey, while nominally under the control of an Ottawa Department, has been in reality an independent institution, recognized as such abroad. Its directors and principal officers have been men whose reputation has far transcended that of the gentlemen who temporarily occupy departmental offices at the seat of government. It is now to be a branch of the Civil Service, a mere appendage to the Department of the Interior. The effect of this may not be felt for a time, but it must eventually tend to deprive the Survey of its independent scientific action, to diminish its importance and consideration abroad, and perhaps in the end to reduce it to a mere industrial bureau, or to place it in the uneasy position of that American Survey of the Territories, which is in like manner attached to the Department of the Interior: but which is there supplemented by the military surveys, and by the surveys of the several states, some of which in their scientific results have far surpassed it. There can be no doubt that considerations of this kind weighed with the eminent and sagacious Canadian who founded the Survey and raised it to its present position of importance, in inducing him so strenuously to oppose its removal to Ottawa. It is to be wished that his fears may not be realised; but I cannot refrain from expressing my own strong conviction that these fears were well founded. The clause providing for the removal of the Survey is, however, not mandatory but only permissive. The carrying it into effect would involve a large expenditure and most serious loss, and would certainly contribute something to the cry beginning to arise, not only in this Province but in those of the Atlantic and Pacific Coasts, that this country is governed, not in the interests of the Empire or of the Dominion in its whole extent, but in those of a section of the people of Ontario. Let us hope

that wiser counsels may prevail, or that some turn of the political wheel may suggest other measures or bring in other men.

The report of the Chairman of Council was next read by Mr. G. L. Marler.

REPORT OF THE CHAIRMAN OF COUNCIL.

At the close of another session, your Council beg to submit the following short summary of its proceedings during the year, with an occasional note on other matters connected with the business working of the Society.

A field-day was held at Belœil Mountain on Saturday, June 10th, 1876, which was attended by about eighty persons, and a very enjoyable day was spent. It is to be regretted, however, that the receipts on this occasion were not sufficient to meet the necessary expenditure, a circumstance probably owing to the unfavourable aspect of the weather at starting.

On the seventh of September last our Scientific Curator and Rec. Secretary, Mr. J. F. Whiteaves, who has held these offices for fourteen consecutive years, tendered his resignation of both, at a special meeting called for that purpose. Resolutions of thanks for his past services, coupled with congratulations on his new appointment and good wishes for his future scientific career, were passed at this meeting.

In consequence of Mr. Whiteaves' resignation, new arrangements were entered into with Mr. Passmore, who agreed to give his whole time to the work of the Society, and to issue circulars for meetings, &c., for which additional services his salary was raised from $200 to $400 per annum.

A Museum Committee was also appointed, consisting of seven gentlemen, whose duties were understood to be to superintend the classification and labelling of specimens in the departments of mineralogy, botany, conchology, entomology, ornithology, and archæology, and to report at stated intervals to the Council on the condition of these collections. The Committee has reported twice since its election, but your Council would suggest the desirability of the appointment of a competent scientific curator who could devote a definite portion of his time to work urgently needed both in the museum and library.

Your Council have to report that ten new ordinary members, two lady associates, and two new corresponding members have been elected during the year. They have, however, to regret the loss of Mr. E. Billings, one of the Vice-Presidents of the Society, and one of its oldest and most zealous members.

The papers read at the regular monthly meetings having been already referred to in the President's address, call for no special notice here.

The free course of Sommerville lectures has been delivered in due course, and the titles of these lectures, the dates at which they were delivered, and the names of the authors, will be found in their proper place in the Society's proceedings. On the nights when these lectures were delivered, the museum was lit up and thrown open free to the public, a privilege of which many availed themselves.

About 1200 persons have visited the museum during the past year, and a large number of these have been admitted free of charge.

In accordance with a recommendation of the Council for the previous year, the walls of the premises have been tinted, and the ceilings whitewashed ; the contents of the cases in the museum have been taken out, and both the specimens and the interior of the cases have been dusted and cleaned.

In October last the use of the rooms was granted free of charge to the Protestant Teachers' Association of the Province of Quebec.

No further action has been taken in the matter of the Fraser Institute.

Finally your Council have to report that the name of Mr. J. Fraser Torrance has been associated with that of Dr. Harrington in the editorship of the *Canadian Naturalist*.

The report of the Scientific Curater and Rec. Secretary was then read by Mr. Whiteaves, as under :

REPORT OF THE SCIENTIFIC CURATOR AND REC. SECRETARY.

The report of the work done in the museum since the last annual meeting embraces only a period of three months, and during this time two days a week were spent at the Geological Survey, by special permission of the Society.

The critical examination of the Marine Polyzoa of the River and Gulf of the St. Lawrence has been almost completed; the Cyclostomata are quite finished, and the Cheilostomata and Ctenostomata nearly so. In the naming of difficult species much assistance has been rendered by the Rev. A. M. Norman, one of the best authorities in Europe on this group, to whom a number of specimens have been sent for comparison, which have been subsequently returned. Mr. Norman has also presented to the Society a large number of named British types.

The fine and interesting collections of marine invertebrates made by Mr. Richardson in 1875 on the west coast of America, have also been carefully studied, and critical forms of molluscs, hydroids, and crustaceans have been sent respectively to Messrs. Dall, Verrill and Smith, which have also been returned. The whole series has now been named, with the exception of the Polyzoa, and a report on the whole is in process of preparation.

Some progress has also been made in the naming and mounting of the shells from the Andamans, presented by Col. Bulger.

A committee of the Entomological Society having requested the loan of rare Canadian insects for exhibition at the Centennial, a series has been selected and forwarded for that purpose. As soon as Mr. Pettit has completed the naming of the Coleoptera, the whole will be returned. In the late Mr. Ritchie's catalogue of the Island of Montreal, the Curculionidæ are omitted, probably because at the time no specialists had worked at this particular group. For some years Mr. Caulfield, Mr. Passmore, and myself have endeavoured to collect as many local species of this order as we could, and last summer, knowing that Drs. Horn and Leconte were engaged in a monograph of the group, all our material was sent to the latter gentleman, who has kindly named and returned all the species.

The rather extensive series of beetles collected in British Columbia by Mr. Selwyn and Prof. Macoun in 1875, has also been packed and forwarded to Dr. Leconte, and a list of them has been published in the Report of Progress just issued. This catalogue is an important addition to our knowledge of the distribution of insect life in the Dominion.

In consequence of the cleaning of the museum and the tinting of the walls mentioned in the report of the Chairman of Council it has been necessary to take down all the ethnological specimen

which were hanging in the gallery. These have been re-hung in their places, but the labels for them have to be re-written. The mammals, birds, reptiles and fishes have also all been taken out of the cases, and after the inside of the latter had been dusted and cleansed, their previous contents were re-placed.

Appended to this short report is a general summary of the condition of the collections, at the date of my resignation of the office of Curator of the Museum.

MINERALS.

These are arranged in four series as follows:

1. *The Holmes Collection.* This originally consisted of about 4000 specimens, principally from the United States and Europe. A written catalogue accompanies it, but many of the original specimens were missing before the erection of this building. Cardboard labels corresponding to those in the catalogue are affixed on or near to each specimen.

2. *Canadian Rocks and Minerals.* A poor collection, of which a catalogue exists. It has been supplemented by some subsequent donations, but no special effort has been made to perfect it, in consequence of the presence in our midst of the fine and almost complete collection of the Survey. All the specimens are labelled like those last named, but both require going over, as some of the tickets may have become detached or misplaced.

3. *A fine series of the Volcanic Rocks and Minerals of Vesuvius and its neighbourhood.* All in good order and labelled, doubtful specimens having been kindly examined and determined by Dr. T. Sterry Hunt.

4 *Miscellaneous Rocks and Minerals.* All labelled, with the name of the species and the locality from which it was collected, when known.

FOSSILS.

The fossils in the museum are mostly from the United States and Europe, the intention being to supplement the Survey Collection as far as possible, and to illustrate such manuals as those of Lyell, Phillips, Jukes and Dana. All are named and labelled, but only a portion of the late Sir Duncan Gibb's donation has been incorporated into its place in the general series.

PLANTS.

A collection filling 21 portfolios of North American plants, arranged according to the Natural System. Although corrosive sublimate was mixed with the paste with which the plants are fastened to the papers, it has been recently noticed that a small beetle has been and is still making burrows through some of the fasciculi, and the matter requires immediate attention.

INSECTS.

Some additional species, mostly scarce Coleoptera, have been added during the year, which were collected by Mr. Passmore and myself. My reports for the past two years give a detailed account of the work done in this department. It was found during the summer that the larvæ of *Dermestes lardarius* had done some damage to a few Lepidoptera in one of the drawers, and the specimens affected were destroyed, and measures were taken to prevent further injuries from this source, but the cabinet will always require periodic inspection.

MOLLUSCA AND MARINE INVERTEBRATA.

This part of the collection is in tolerable order, but the nomenclature of the species requires some revision.

FISHES AND REPTILES.

The stuffed specimens are in fair condition, though some improvement can be made in the labelling of the Canadian fishes, which were identified only in a provisional kind of way several years ago. A commencement has been made of a new collection of alcoholic preparations, which are temporarily placed in the vestibule, but this part of the work was stopped for want of a supply of good glass stoppered bottles and of alcohol.

BIRDS AND MAMMALS.

The series, especially of native species, badly wants replenishing with new and fresh specimens; but those we have, though though mostly old and often in very poor condition, are all carefully named. The Society's collection of the eggs of North American birds, is very good, and could be made of much value to students at a very trifling expense.

MISCELLANEOUS.

A number of objects of interest, such as Indian antiquities and modern ethnological objects, have been temporarily arranged in the best manner the cases at my disposal would admit. Quite a large number are contained in drawers, &c., there being no cases available for their proper exhibition.

THE GULF DREDGINGS.

The history of these investigations may be briefly summed up as follows: In 1867 and 1869 dredgings in the Gaspe district were carried on at my sole expense in the summer months, and these require no further comment. In 1871 the Government gave me, as the Society's representative, a passage and some opportunities for dredging on government vessels. The cost of the necessary outfit and travelling expenses, amounting to about $120 or $130 were shared by the Society and myself, the Society paying about $90, and myself between $30 and $40. In 1872 and 1873 the Government defrayed all the expenses, but the Society paid my salary during the time of my absence.

All the alcoholic and many of the dry specimens obtained in these dredgings, with the exceptions which will shortly be noticed, are placed provisionally in a large cupboard in the vestibule, with five compartments, which was constructed for the purpose. A few of the mollusca and celenterates are incorporated into the general series in the gallery.

The whole of the collection of marine worms has been sent to Dr. McIntosh of Murthley, by Dunkeld, in Fifeshire, who is engaged in their examination, and who has published a report on part of them in the Annals of Natural History.

A few critical Polyzoa are also in the possession of the Rev. A. M. Norman.

The Ostracoda, which have been studied and reported on by Messrs. Robertson and Brady, have not yet been returned, but are still in the hands of the former gentleman.

Duplicates have been sent to Professors Verrill and Smith, of Yale College, and to Mr. Alfred Brown of Glasgow. From the former gentleman the Society has received a named series of marine invertebrates from their dredgings on the New England coast; and from Mr. Brown a number of species of exotic shells.

As soon as I can find time to put my notes into shape, I propose to publish a final report on the results of the whole of these dredgings.

COLLECTIONS DEPOSITED BY THE GEOLOGICAL SURVEY.

These consist of marine invertebrates from the Gulf of Georgia and other parts of the west coast of British North America, for the most part dredged or collected by Mr. James Richardson, also of a collection of dried plants from the Pacific coast made by the same veteran explorer. These require to be labelled with tickets stating clearly to whom they belong, in case they should be claimed by the Government or by the Directors at any future time.

Finally, while resigning the offices of Scientific Curator and Recording Secretary, permit me to express the hope that the members generally will overlook or excuse any shortcomings or remissness on my part during the past fourteen years, and that they will believe that my sole object during this long period has been to endeavour to promote the advancement of knowledge and to popularize the study of Natural History in this city.

Mr. E. E. Shelton, as Treasurer, submitted the annexed financial statement:

Dr. THE NATURAL HISTORY SOCIETY OF MONTREAL, *in account with* E. E. SHELTON, *Treasurer.* *Cr.*

1876-77.		1876-77.		
To Cash paid Mr. Whiteaves, salary	$200.00	By Balance in Treasurer's hands, May 17, 1876		$603.92
" Mr. Passmore, "	325.00	" Cash received, Government Grant		750.00
" " " attend. meetings last year.	28.00	" " Member's Yearly Subs.—Ladies	$8.00	
" Mr. Foote, commission on collections	24.30	" " " " " Gentlemen	500.00	
" for Coal	131.45			508.00
" Gas Bills	77.15	" " Museum Entrance fees		34.75
" Water	43.95	" " Rent of rooms		432.00
" City Taxes, (overcharge $49.10 returned)	128.20	" Interest on Deposit in Bank		9.67
" Corporation for New Drain	84.75			
" Interest, Royal Institution	80.00			
" Insurance	36.05			
" Dawson Bros. for Naturalist	177.50			
" Whitewashing and Petty Expenses	162.48			
" Printing and Advertising	90.17			
" Loss on Excursion	40.93			
'77. May 16—To balance in Treasurer's hands	708.41			
	$2338.34			$2,338.34

LIABILITIES:

Mortgage on Society's Buildings in favor of Royal Institution $1000.00

MONTREAL, 17th May, 1877 } Audited and found correct, after comparing Vouchers, &c.

J. H. JOSEPH,
G. L. MARLER.

It was moved by A. R. C. Selwyn, seconded by Dr. J. Baker Edwards, and resolved:

"That the reports just read be adopted and printed separately for distribution to the members."

On motion of Mr. A. R. C. Selwyn, seconded by Mr. G. L. Marler, it was resolved unanimously:

"That Dr. P. P. Carpenter and Mr. J. F. Whiteaves be elected Honorary Life Members of the Society."

It was moved by Mr. Marler, seconded by Dr. J. Baker Edwards, and carried by acclamation:

"That the bye-law relating to officers be suspended, and that Principal Dawson be re-elected President."

Mr. Selwyn moved, seconded by Mr. Marler:

"That Mr. E. E. Shelton, be re-elected Treasurer."

The motion was carried unanimously.

On motion of Mr. Marler, seconded by Dr. J. Baker Edwards, Mr. F. W. Hicks, M.A, was elected Corresponding Secretary; and on motion of Mr. Selwyn, seconded by Mr. Shelton, Dr. J. Baker Edwards was elected Recording Secretary.

Messrs. M. H. Brissette and A. H. Foord having been elected scrutineers, the following gentlemen were elected officers, by ballot.

Vice-Presidents—Rev. A. DeSola, LL.D.; His Lordship the Metropolitan; Prof. P. J. Darey, M.A., B.C.L.; Dr. P. P. Carpenter; G. L. Marler, C. Robb, A. R. C. Selwyn, F.R.S., F.G.S.; Jas. Ferrier, Jr.

Council—Dr. W. Osler, R. W. McLachlan, J. F. Whiteaves, Prof. R. Bell, M. H. Brissette, J. H. Joseph, Dr. B. J. Harrington, J. B. Goode and W. Muir.

It was moved by Mr. Shelton, seconded by Dr. J. Baker Edwards, and resolved:

"That the members of the Library and Membership Committee be re-elected and that the names of Dr. Wolfred Nelson and J. Fraser Torrance be added to their number."

On motion of Dr. Wolfred Nelson, seconded by Mr. F. W. Hicks, a vote of thanks was passed to the officers of the past year, and a special vote to the same effect was also passed to the Scientific Curator for fourteen years services in that capacity, the mover being Mr. W. Muir and the seconder Dr. J. Baker Edwards.

APATITE : ITS MODE OF OCCURRENCE IN NORWAY.

The February number of *The British Mercantile Gazette* contains an interesting article on "Norwegian Phosphates," which we republish here, somewhat abridged, in the belief that it cannot fail to prove of value to such Canadian readers as may be interested in the great apatite deposits of Burgess and Ottawa County.

The palæozoic rocks of Norway correspond so closely to our Laurentian series, and the modes of occurrence of the chief deposits of minerals of economic value are so similar in the two regions that any practical information about the Norwegian apatite must benefit those engaged in mining here.

"It is, relatively speaking, but a few years since the Norwegians learnt the value and importance of their apatite mines. These mines are generally found at the bottom of granite rocks, and where the mines exist there appears on the surface an outcrop of the bed. These veins proceed from the principal deposit; they are of variable dimensions, but ordinarily very large, from 100 to 200 feet deep. . . . They are narrow at the surface, generally increasing in size as they approach the nucleus. A few of these veins contain, at variable distances, irregular pockets, more or less spherical, from six to eight feet in diameter, called roses.

"Those who were first engaged in the extraction of apatite, contented themselves with emptying these pockets. . . The veins are always enclosed in the granitic strata, and are conformable to their dip. At times the vein is suddenly broken and interrupted by the presence of an irregular mass of rock, but by continuing the work of extraction it will be found again in the same direction, a few inches lower, and ordinarily larger. It was through inexperience on the subject that in the beginning the Norwegians only worked the veins a short depth and then abandoned them.

"The greater part of the veins of apatite are surrounded by a thick layer of black mica or of hornblende. Science has not yet been able to determine the cause of their presence in this case where they enclose the apatite like a sheath or thin skin existing between the granite and the apatite vein. . . . The name

of apatite is given to very pure crystallised phosphate, averaging from 85 to 95 per cent. of phosphate. The apatite mines of Norway are but few, and all situated within an area of forty square miles The worst situated of all is that of Bamble, which lies a few leagues in the interior on the other side of the ports of Langesund and Bervil. The apatite of Norway is not quite uniform, but its richness does not vary much. It never yields under 85 per cent. The apatite we have seen and analysed gives about 91 per cent. tribasic phosphate of lime.

"The veins are generally from one to two feet thick at the surface, but on following them to fifty feet deep they are often found to increase to six or seven feet thick, and each vein is often from twenty-five to one hundred feet in length, more or less, and descends to an unknown depth. The apatite is massive and hard, and to extract it pits must be sunk, as the more the veins are dug the larger they grow. From this it should have been inferred from the beginning that at a depth of from 150 to 200 feet they would unite to a massive bed, of which these are but branches.

"At Bamble, in the month of June last year, a large bed was discovered after a vein had been followed to a depth of 160 feet. This fact confirms the preceding statement, and augurs well for the future of these apatite mines.

"The Norway apatite is generally crystallised and compact. In a few of the veins it is of a white colour, in others of a yellowish green or of a red tint.

"The mines of Husaas in the Bay of Risoer, are the principal and best situated in Norway. This large and important concession is perpetual, and free from all taxes. It comprises an area of about 1600 feet long and 800 feet wide. The mine is situated at from 200 to 300 feet from the shore in the interior of the bay, where it is deep enough for even the heaviest ships to load easily. From the mine to the ship, the distance being so short, expensive transport is avoided In these mines there are two large veins of white apatite of exquisite formation and great purity, containing from 89 to 91 per cent. of tribasic phosphate. One of the two lodes is 200 feet long. The other has not been worked so much, and has only been followed 90 feet, but there is every reason to believe that it extends much further. This remains to be verified, and is of secondary importance. The thickness of the veins naturally diminishes towards their extremities. As it is very large at their surface, we believe that the bed from which they emerge cannot be very deep, and that the thickness of the veins will double at about 50 feet. But calculating at a minimum upon their actual thickness, it may be stated that if, over their length, at distances from ten to twenty feet apart, only ten pits were dug six feet deep, from three to four tons of apatite per yard dug could be extracted, or for the united ten pits thirty tons per day. This would not take more than half a day, and would allow 18,000 tons to be extracted in a year of 300 working days.

"At the same estate of Husaas, at a few yards from the apatite mines and parallel to them there is a vein of nickeliferous and cobaltous pyrites which gives, according to the analysis of well known chemists of Christiania, from 2 to 2.70 per cent. of nickel and cobalt. This lode is narrow at the surface. It may be remarked that an analagous vein near Drammen attained the thickness of 30 feet at a depth of one hundred feet, and now returns fabulous profits to the proprietor. Considered on the whole, the mines of Husaas, for exceptional situation and importance, are without rivals in Norway.

"There are also in the same country, at a few leagues distance one from the other, two other rich apatite mines belonging to the Belgian Consortium. The first is the apatite mine of Noland Spiremir, situated at Rod Akeland, and is finely placed on tho road separating the sea-ports of Sondeled and Rod, and is about a mile and a half from Rod, and three miles from Sondeled. The mine is on a slope of the mountain bearing the same name, and the concession is very large, covering several acres. There is but one vein, but it is of extraordinary power. Its length is about one hundred feet, and its breadth nine feet. Its depth is unknown, that is to say, it is not known whether 100 or 150 feet would be dug before coming to the massive layer. The vein is so exceptionally large that it is taken for granted that its extraction would immediately bring handsome profits. Only at the top the vein is irregular and strewn with fragments of rather soft stone, which may be easily picked out with a small hand pick from the blocks of apatite extracted. It is now being worked with a view to examine and compare its purity at a depth of twenty feet with that at the surface. The apatite of this mine is of a rose colour, and yields 89 per cent. of pure phosphate. As the mine is but a few yards from the grand road, and only forty-five minutes walk from the sea-ports of Sondeled and Rod, between which it is situated, it could be nearly as advantageously worked as that of Husaas."

The reports of our Geological Survey show that the apatite of Burgess is usually accompanied by quantities of mica and hornblende or pyroxene, and is bedded in Laurentian gneiss. In so far its mode of occurrence closely agrees with that of the Norwegian phosphate. But the Burgess deposit occurs in shallow synclinals, and at only one point has it been tested to a depth of over 100 feet. The deposits in the County of Ottawa are yielding a purer mineral, and may possibly extend to a far greater depth. The magnetic pyrites of the Laurentian usually contain some nickel and cobalt.

In Mr. Vennor's report for 1873 the causes of the poor success of most of the phosphate mines in Burgess and its vicinity are accurately determined and clearly explained. A study of this record may save some of our capitalists much trouble and disappointment when engaged in opening up the beds of apatite on the shores of the Lievre.

Fig. 1.

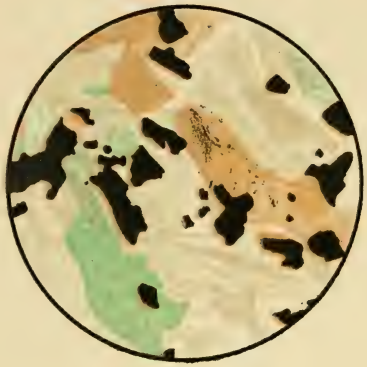

Fig. 2.

Fig. 3.

Fig. 4.

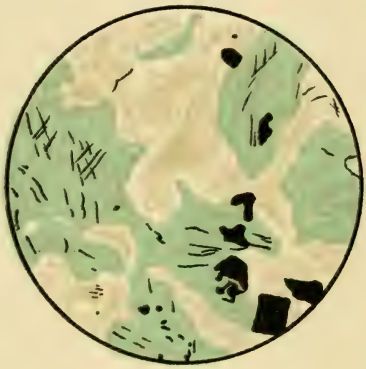

Fig. 5.

Fig. 6.

a.

b.

c.

THE

CANADIAN NATURALIST

AND

Quarterly Journal of Science.

NOTES ON A FEW DYKES CUTTING LAURENTIAN ROCKS, MORE ESPECIALLY WITH REFERENCE TO THEIR MICROSCOPIC STRUCTURE.

By B. J. Harrington,

Of the Geological Survey of Canada.

The fact that rocks of Laurentian age are frequently cut by trap dykes, was many years ago noticed by Sir William Logan, who traced out and mapped a number of those found in Grenville and some of the neighbouring townships. Since then other observers have noted their occurrence in widely distant Laurentian areas. Mr. Vennor, for example, observed dykes in Madoc and North Burgess. Mr Macfarlane in his report on Lake Superior* describes dykes which cut the Laurentian rocks at Goulais Bay, Gros Cap, and other localities, and from his descriptions some of them appear to resemble those found in Grenville. At Goulais Bay they are from nine to seventy feet thick, strike N. 72° to 75° W., and are probably doleritic. Others at Gros Cap and the mouth of the Montreal River Macfarlane also considers to be dolerites, but states that near Michipicoten Harbour, and in Bachewahnung Bay, there are dykes of diorite. He further states that at two different points in the Laurentian area examined by him, he observed intrusive rocks of the character of the "newer traps or melaphyres which characterise the upper copper-bearing series."

* Geology of Canada, 1866, p. 120.

Professor Bell, of the Geological Survey, has repeatedly noticed the occurrence of dykes in the regions explored by him north of Lakes Superior and Huron, and states that in some parts of the country they form a conspicuous feature in the geology, and have probably played an important part in producing the present geographical features. One described by him as a diorite in the report of the Survey for 1875–76 (p. 314) is said to be from 300 to 400 feet in width. Its course is N. 12° W., and it cuts a thinly bedded micaceous gneiss nearly at right angles to the strike of the latter.

Mr. G. M. Dawson has also given us a number of facts concerning dykes at the Lake of the Woods, where they are said to be both granitic and dioritic. Some of the latter, which are coarse-grained and apparently have general east and west courses, "may very probably be among the oldest of the intrusions." There are others, however, which are very hard and compact, and have a general bearing of north-east and south-west. These cut not only the intrusive granites of the region, but also the altered Laurentian strata.*

The late Mr. Walter McOuat has mentioned the occurrence of dykes of "diorite" from fifty to one hundred feet thick at several localities between lakes Temiscamang and Abbitibbe, and states that the apparent direction of two large ones on Lac des Quinze (on the Upper Ottawa) is north-by-east and south-by-west. †

It is therefore evident that in almost all parts of the country where the Laurentian rocks have been examined, they have been found to be cut by dykes of various intrusive rocks, few of which have, however, been critically studied as yet.

The intrusive rocks of the Grenville region are of special interest, inasmuch as most of them were shown by Sir William Logan to belong to a date anterior to the deposition of the Lower Silurian. According to the descriptions given in the Geology of Canada, they consist of dolerite, syenite and felsite porphyry. Of these the oldest "are a set of dykes of a rather fine-grained dark greenish-grey greenstone or dolerite, which weathers greyish white." * * * "Their width varies from a few feet to

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* See Report on the Geology and Resources of the Region in the vicinity of the Forty-ninth Parallel. 1875. pp. 25, 53.

† Report of Progress, Geol. Survey, 1872-73, pp. 120, 122 and 130.

a hundred yards, and they possess a well marked columnar structure. Their general bearing appears to approach east and west, but the main dykes occasionally divide, a branch striking off at an angle of from twenty to forty degrees." Some of them have been traced for many miles, cutting both the limestones and gneisses, and sometimes forming a ridge across the limestone and a hollow in the gneiss. Whenever they are seen to come into contact with the syenite they are interrupted or cut off by it, being therefore more ancient; and "the relations" Sir William states "of the base of the Lower Silurian group along the foot of the hills composed of the syenite are such as to make it evident that the Silurian beds in some places overlie eroded portions of the intrusive rock." All the intrusive rocks of this region are, however, cut by a set of dykes the relations of which to the Silurian series is not known. They were described in Sir William's original report under the name of melaphyre, but were afterwards designated by Hunt as dolerites, though differing considerably in characters from the older rocks of that name.

The writer regrets that he has not had an opportunity of visiting any of the places mentioned above, or even of seeing authentic specimens of any of the dykes, with the exception of a few from Grenville and two or three other localities. These specimens have, however, been sliced and studied microscopically, and a few notes on their microscopic characters may be of interest.

MICROSCOPIC CHARACTERS.

I. *Grenville, Lot* 9, *Range IV.* (Plate, fig. 1) The examination of a specimen from this locality shows it to consist of plagioclase feldspar, augite, magnetite, viridite,* apatite, and a little mica and iron pyrites. The plagioclase forms a very considerable proportion of the rock, and although much of it has undergone alteration and lost its transparency, it still shows in places, with polarised light, the banded appearance common in plagioclastic feldspars. It has evidently crystallised before the augite, as blades of it are frequently seen to penetrate the latter mineral. The augite is pale brown or in places pinkish in colour. Its form has, for the most part, been impressed upon it by the

* This useful name is applied to a number of green substances which often result from the decomposition of augite, hornblende and olivine, and which cannot always be "individualised."

other minerals, but here and there a rude crystal may be observed. The mica is present in small quantity, and is brown and strongly dichroic. Magnetite (possibly titano-ferrite) is abundant, occuring chiefly in irregularly shaped grains, but sometimes showing rude octahedral form. Sometimes it is seen in innumerable small grains imbedded in the augite. The viridite is abundant and very bright green. It occurs largely in fibrous or sheaf-like aggregations showing faint dichroism, and with the polariscope changing, on rotation of the analyser, from blue to brown. In all probability it is chlorite. The apatite is found in sharply defined acicular crystals which are hexagonal when seen in cross section. It is most abundant in the feldspar, but is also seen to penetrate the mica, augite, and even the magnetite.

II. *Grenville, Lot* 9, *Range V.* When examined with the microscope the section of this rock is, like that last described, seen to consist of plagioclase, augite, magnetite, viridite, pyrite and apatite? The feldspar forms a network of blades, and has in places undergone some alteration, although for the most part it appears to be unaltered and with the polariscope becomes beautifully banded. It is distinctly seen to penetrate the magnetite in a number of instances, and must therefore have solidified before, or at least simultaneously with the magnetite. It also contains a good many of what appear to be glass- and stone-cavities. The augite is brownish-grey in colour, traversed by numerous fissures and penetrated in all directions by blades of feldspar. The rock contains a good deal of magnetite, mostly in grains of irregular form, but occasionally in octahedral crystals. When cut across the grains are often seen to contain numerous irregular cavities, and in one case an octahedral crystal was observed which was hollow, or nothing more than a shell. Viridite is present in considerable quantity. It is much duller green than that in the rock last described, and looks more like an alteration product of the augite. It is mostly amorphous, but occasionally occurs in sheaf-like aggregates. Pyrites is present in small irregular grains scattered here and there through the rock.*

* Specimens I and II were many years ago analysed by Dr .Hunt, who described them as follows: "The dykes of this most ancient dolerite or greenstone in Grenville have a well-marked columnar structure at right angles to the plane of the dyke. They are fine-grained, dark greenish-gray in color, and weather grayish-white.

III. *River St. Simon.* (Plate, fig. 2.) This specimen is from a fine-grained, greyish-black dyke which cuts the Green Lake band of crystalline limestone on the St. Simon, a small tributary of the North River, in Terrebonne County east of Grenville. I am indebted for it to the Director of the Geological Survey. The dyke probably belongs to the same set as the Grenville ones just described, its general structure being the same, but it has apparently undergone very little alteration, the section being beautifully clear and transparent. With the microscope it is seen to consist of a network of plagioclase feldspar, with augite, magnetite and apatite (?) and a very little viridite. The feldspar as seen in the section is perfectly transparent and colourless, and with the polariscope shows a beautifully banded structure. In places it contains microlites which are possibly apatite, and also a few vapour- or gas-cavities, generally in groups. The augite is pale greyish-brown frequently penetrated by blades of feldspar and often containing groups of minute grains of magnetite. It appears to constitute about half the rock. The magnetite occurs mostly in irregular grains and masses of most fantastic shape, but now and then in rude crystals and rod-like forms. In some cases it is seen to be penetrated by blades of feldspar. (See figures on next page.)

The viridite is not very abundant and looks as if derived from

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Under a lens the rock is seen to consist of a greenish-white feldspar with a scaly fracture, mingled with grains of pyroxene, occasional plates of mica, and grains of pyrites. It contains no carbonates. Two analyses of portions of the dolerite from dykes differing a little in texture gave as follows:

Silica	50.35	50.25
Alumina	17.35	32.10
Peroxyd of iron	12.50	
Lime	10.19	9.63
Magnesia	4.93	5.04
Potash	.69	.58
Soda	2.28	2.12
Volatile	.75	1.00
	99.04	100.72

"The iron in these analyses, although given above as peroxyd, exists in the form of protoxyd, and in the second specimen, in part as a sulphuret." (Am. Jour. of Sci., 1864, 2nd Ser., Vol. xxxviii, p. 174.) Which of the analyses applies to the specimen from Range IV and which to that from Range V is not stated.

the augite. It is rather dull green and can scarcely be said to exhibit dichroism. In places it shows numerous fine lines running in several directions.

Figures 1 and 2.—Grains of magnetite penetrated by blades of feldspar. (× 78.)

Figure 3.—Group showing a few of the varied forms which the magnetite assumes. (× 78.)

IV. *River Gagnon, Terrebonne County.* (Plate, fig. 3.) The specimen from this locality is coarser in texture than the last, and of a dark grey colour. Its specific gravity is 3.013. The dyke where observed by Mr. Selwyn (to whom I am indebted for the specimen) cuts a band of gneiss, and is in all probability of the same age as the Grenville ones, though it has not been traced out. The examination of a thin section of the rock shows it to be composed of plagioclase feldspar, augite, magnetite, apatite and a little mica and viridite. The plagioclase shows evidence of but little alteration, and much of it is striated as in the case of the River St. Simon rock, and with polarised light beautifully banded. The blades run in all directions, but do not constitute as continuous a network as in the last specimen, since the augite is much more abundant. Blades of the feldspar frequently penetrate the augite, and occasionally also the magnetite. The augite is pale brown in colour, perfectly fresh, and often dotted with what appear to be gas-or vapour-cavities. Its cleavage is often well-marked and it occasionally shows twinning (see figure). The magnetite is not very abundant and occurs in irregular and often fantastic forms. The apatite and mica are present in very small quantity, as is also the viridite. The latter chiefly accompanies a brown somewhat decomposed mineral which has not been determined. With polarised light the section forms a beautiful object.

V. *Grenville, Lot* 4, *Range VI.* The specimen from this locality is from one of the newer dykes which, as already stated, cut all the other rocks of the region. It consists of a dark grey fine-grained base (sp. gr. 2.83) with occasional porphyritically imbedded masses of hornblende, which are often accompanied by a plagioclase feldspar. Calcite is also present in white cleavable masses, mostly filling cavities.*

Microscopically this rock is very different from those already described, but it requires much further study. The ground-mass appears to consist of a mixture of plagioclase, biotite (very abundant), and magnetite or titano-ferrite, with a good deal of a green mineral which is probably an alteration product, and is not at all dichroic. Here and there also there are almost colourless crystals, which may prove to be olivine, very much cracked, and often converted along the cracks into a pale green mineral. As stated above, the rock is porphyritic, and a section cut across one of the porphyritic masses shows it to consist of beautifully striated plagioclase with embedded crystals of hornblende and a little pyrite, while all these three minerals contain numerous crystals of apatite, the largest cross sections of which measure about 0.25 mm. Some of the cross sections are perfect hexagons, but none of the crystals when viewed longitudinally show perfect pyramidal terminations, but are generally rounded as seen in figure 6 c of the accompanying plate. When examined with a high power, most of them are seen to contain numerous cavities, which in a few instances have been observed to contain bubbles, although most of them appear to be empty. Almost without exception, too, they contain black globular and sub-globular bodies (see plate), which possibly take the place of the thin nail-like bodies often found in the apatite of basalt. Some of the crystals contain

* An analysis of this rock was published by Dr. Hunt in the Geology of Canada and also in the American Journal of Science (Second Series, Vol. XXXVIII., p. 174) from which the following is extracted: "When in powder the rock effervesces freely in the cold with dilute nitric acid, and the solution evolves red fumes on heating. In this way there were dissolved, lime, equal to 8.70 per cent. of carbonate, 0.50 of magnesia, and 6.50 of alumina and oxyd of iron = 15.70 per cent. The residue dried at 212° F., equalled 83.80 per cent. A portion of aluminous silicate had evidently been attacked by the acid. The dried residue gave on analysis, silica 52.20, alumina 18.50, peroxyd of iron, with some titanic acid, 10.00, lime 7.34 magnesia 4·17, potash 2.14, soda 2.41, volatile 2.50 = 99.26."

only only one or two of these, but as many as nine have been observed in one case. The rude crystals of apatite which are associated with pyrite are cracked across, and the cracks filled with pyrite as shown in figure 5.

The amygdules have a lining of a green structureless mineral (green earth) while the interior is filled with a colourless mineral which appears in most cases to be calcite. In some cases also the cavities contain pyrites, mostly at the junction of the calcite and green earth.

VI. *Madoc, Ontario, lot* 24, *Range VI.* (Plate, fig. 4.) This rock may be noticed here as a good example of a diorite. It was given to me by Mr. Vennor of the Geological Survey, and stated to have been broken from an undoubted dyke. It was supposed to be a pyroxenic rock, but the microscopic study of a thin section shows it to be a diorite, consisting chiefly of feldspar, hornblende and magnetite, but also containing cubical crystals of iron pyrites and small quantities of a transparent mineral which is probably quartz. The feldspar is a good deal altered, but apparently all plagioclase in the sections examined. The hornblende is of a rich green colour, and much of it shows cleavage lines very distinctly. It is dichroic and polarises beautifully. In places it appears to have undergone some alteration, though not to the same extent as the feldspar.

Conclusions. The first of the rocks just described, on account of the large proportion of viridite which it contains, and the altered state of the feldspar, would be called by German petrographers a diabase. One would also expect to find a larger proportion of water than is indicated by the analysis. In many respects it agrees with Senfter's descriptions of diabase from the Duchy of Nassau in Germany. The alteration which it has undergone, however, is not nearly as marked as in many diabases from much younger formations, as, for example, the Cretaceous of British Columbia. Much of the viridite looks as if it had been one of the original constituents of the rock, but in other places it is pretty evident that it has been derived from the augite.

No. II may perhaps also be called a diabase, although very little removed from such rocks as III and IV. Its general structure is the same, the only important difference being the development of a good deal of viridite. Nos. III and IV are true dolerites or "feldspar basalts," indistinguishable from many

of Tertiary age. They are highly crystalline and do not appear to contain any glassy base. As yet no olivine has been observed either in them or the diabases, but very few sections have been examined, and possibly it will be found on further study. In No. I, a mineral has been observed with the characters of sanidin, and no doubt other minerals will yet be detected.

The order in which the different minerals have solidified is a matter of interest, apparently not being that of the fusibilities of the constituent minerals before the blowpipe. In the diabase and dolerite it is evident that the apatite has been the first to solidify; the plagioclase appears to have come next, then the magnetite, and last of all the augite. Mr. J. Clifton Ward gives an interesting example of the apparent order in which the minerals constituting a leucitic basalt near Naples have solidified, which may be noticed in this connection. The minerals are leucite, magnetite, magnesia-mica, feldspar and augite. Of these five minerals the only infusible one is the leucite, and yet Mr. Ward thinks that the last four "were held in solution by leucite in a state of fusion; and that instead of this mineral crystallising out first, it deposited in succession the magnetite, the mica, the feldspar and the augite, and last of all probably solidified quickly, enclosing within its crystals glass- and stone-cavities, and magnetite and feldspar crystals."

It is evident that No. V is a very different rock from any of the others described. In some respects it resembles the so-called melaphyres, but contains much more mica than is found in any of which I have seen descriptions. No. VI is as already stated a diorite and needs no further remark here.

The slight amount of alteration exhibited by some of the ancient dolerites in the Grenville region would no doubt be surprising to some, but is not so much to be wondered at when we consider that they occur in highly crystalline rocks, which would serve to a great extent to protect them from the agencies which have brought about decomposition in dykes cutting the unaltered strata of some more recent formations.

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* Quart. Jour. Geol. Soc. 1875, p. 396.

DESCRIPTION OF PLATE III.

FIG. 1. Diabase from Grenville, lot 9, range IV, showing augite plagioclase, magnetite and viridite (magnified 28 diameters).

FIG. 2. Dolerite (Feldspar Basalt) from River St. Simon, showing augite, plagioclase, magnetite and a little viridite. The cruciform group in the right hand upper corner is plagioclase. (x 78).

FIG. 3. Dolerite from River Gagnon, showing augite (a twin on the left) plagioclase and magnetite. (x 14).

FIG. 4. Diorite from Madoc, Ontario, showing bluish-green hornblende, plagioclase, magnetite, and pyrite (the square crystal in the lower right hand corner). (x 78).

FIG. 5. Apatite in rock from Grenville, lot 4, range VI. The portion of the drawing shaded black, excepting the spots in the apatite crystals, consists of magnetite and pyrite, chiefly the latter. (x 78)

FIG. 6. (*a*). Cross section of apatite crystal with numerous cavities a few of which show bubbles, and are perhaps liquid cavities. (*b*). Cross section of apatite crystal, showing the black bodies referred to in the text. (*c*). Longitudinal section of rounded apatite crystal with black bodies similar to those in *b*. (All x 78.)

NOTES ON THE SURFACE GEOLOGY OF NEW HAMPSHIRE.

By Warren Upham.

The following notes on the Drift or Post-pliocene deposits of New Hampshire, are based upon explorations made in 1875 and 1876 for the State geological survey.

To explain the striæ, till, or boulder-clay, and modified drift, which are found in all northern coun'ries, has been a most difficult task, about which some diversity of opinion still remains. The surface geology of New Hampshire seems to require the bold theory of Agassiz, that an ice-sheet swept over our territory from the North. This continental glacier became sufficiently deep to cover every mountain summit in the State. That it overtopped Mount Washington has been recently discovered by Prof. C. H. Hitchcock, State geologist, who has found transported rocks, and shown that glacial drift or till underlies the angular blocks at the summit. Its thickness farther to the north was so much greater than in this latitude, that its immense weight caused the ice to flow slowly outward. The direction of its current in New England was between south and south-east. Its terminal front in the United States coincided nearly with the course of the Missouri and Ohio rivers, passing into the ocean south of Long Island. Its greater extent east of the Missouri resulted from the increased snow-fall of this side of the continent.

The conditions which brought on the severe climate of this period have been the subject of much speculation and discussion. Mr. James Croll, with much probability, refers the ice-sheet to an astronomical cause, and claims to determine the date and duration of the glacial period. He supposes that an ice-sheet was produced several times about each pole, a glacial epoch in the northern hemisphere being one of genial climate at the south pole, in which the ice-sheet disappeared.* It is certain that the ice was partially melted at times, and that it afterwards advanced, covering the territory from which it had retreated; but the long period requisite for the formation of the ice-sheet, and the low

* Croll's "Climate and Time," pp. 76-78, etc.

temperature of the altitude to which it reached, render it improbable that it was several times wholly melted away.

Near the end of the glacial period, we have proof that the sea stood 100 to 200 feet higher than now along the coast of New England, and about 500 feet above its present level in the valley of the St. Lawrence. It seems quite probable that this submergence was produced by the attraction of the ice, which, as pointed out by Adhémar, would draw the ocean away from the equator towards the poles. The whole amount of water in the sea was diminished; but the accumulation of vast sheets of ice, probably several miles in thickness, would be sufficient to retain the ocean at its present height near their lower limits, while it would rise much higher than now about the poles, and at the equator would sink far below its present level. Such a rise of the sea, increasing in amount in high latitudes, is attested by the modified drift of both America and Europe; and coral islands afford proof of the corresponding depresssion of the ocean, succeeded by a gradual elevation to its present height, over large areas within the tropics. The two great continents appear to have existed, with somewhat the same outlines as now, from a very remote geological epoch. From the Silurian age to the glacial period we have no record that any part of New Hampshire was submerged beneath the ocean. This long stability makes it more probable that these recent changes in the relative heights of land and sea, are due to the cause which we have explained, rather than to any downward and upward movement of the earth's surface.

Three divisions of Post-pliocene time are well marked in New England, and apparently in all countries which have been overspread by ice. They are distinctly characterized as successive periods of glaciation, deposition, and erosion. The first is the *glacial period*, during which the ice-sheet prevailed, moving over New Hampshire towards the south or south-east, as shown by striæ throughout the State. These glacial markings appear to show the last direction in which the ice moved, since the latest wearing necessarily effaced previous striæ. We therefore learn that the ice finally retreated from New Hampshire towards the north-west and north, and from the region of the Great Lakes and along the St. Lawrence valley towards the north-east.

As the ice-sheet slowly advanced during this period, fragments were torn from the ledges, and a large part of these were sooner

or later held in the bottom of the ice, and worn to small size by friction upon the surface over which it moved. The resulting mixture formed beneath the ice is variously called the ground-moraine, boulder-clay, or *lower till*. It consists of smoothed and striated stones, with fine detritus, which is usually a gravelly clay of dark bluish color, being always clayey, dark, and very hard and compact. The characteristics of the lower till are due to the mode of its formation. Most of its pebbles and boulders are glaciated, having round edges and smoothly worn sides, which often retain striæ. These show that the finer material in which they occur has been produced by the slow grinding up of these stones under the ice. The dark and frequently bluish color is due to seclusion from air and water during its formation, as pointed out by Torell, leaving its iron principally in the form of ferrous sulphides, silicates, and carbonates. Its compactness and hardness are due to compression under the great weight of ice. Because of this quality, the lower till is commonly known as "hardpan." The same cause has also produced an imperfect cleavage in planes parallel to the surface, noticeable wherever an excavation has been for a short time exposed to the weather.

While this deposit was thus accumulating beneath the ice, great amounts of material, coarse and fine, were swept away from hill slopes and mountain-sides, and afterwards carried forward in the ice. When this melted, a large portion of the material which it contained fell loosely upon the surface, forming an unstratified deposit of gravelly earth and boulders, which may be called the *upper till*. In New Hampshire there is almost always a definite line of separation, at a depth varying from two or three feet, as is most common, to fifteen or twenty feet, between the upper and lower till. The upper member is the one usually exposed on the surface, and it is often the only one present where only a thin covering of till is found. Its characteristics are the larger size of its boulders, which are mostly angular and unworn; the yellowish or reddish color of its fine detritus, produced by the hydrated ferric oxide to which its iron has been changed by exposure to air and water; and the comparative looseness of its whole mass. This division of the till into two members, which is very well marked throughout New Hampshire, is also conspicuous in Sweden and other parts of Europe; and the peculiar features of each have been recently pointed out by Dr. Otto Torell, of Sweden,* in nearly the same terms here used.

* *American Journal of Science and Arts*, Third Series, Vol. xiii, p. 77.

The boulders which are contained in the upper till, or which lie upon its surface, are of all sizes up to ten feet, or rarely even twenty or thirty feet, in diameter; and in this state, they have nearly all been transported southward from their native ledges. Where an outcrop of rock is so peculiar that its boulders cannot be confounded with those from other ledges, we may trace them southward or south-eastward, but not in other directions. They are abundant near their source, and diminish in numbers and size as we advance. The till of New Hampshire contains boulders which are thus known to have travelled a hundred miles.

The distribution of the till in this State and in eastern Massachusetts is quite irregular. Sometimes no considerable accumulations of it are seen for several miles, and the ledges lie at or near the surface. Elsewhere the till occurs in large amount, covering the ledges, which are scarcely exposed over some whole townships near the coast. Wherever it is found plentifully, it is to a large extent massed in peculiar oblong or sometimes nearly round hills. which usually have quite steep sides and gently sloping rounded tops, presenting a very smooth and regular contour. These hills are of all sizes up to one-third or one-half mile long, with two-thirds as great width; and their longest axis is most frequently north-west to south-east, coinciding nearly with the current of the ice sheet. Their height varies from forty or fifty to two hundred feet. These accumulations of till are very prominent near the coast, where they sometimes occupy nearly the whole territory for many miles, while adjoining areas on each side may be almost destitute of surface deposits, showing only naked, striated ledges.

About Winnipiseogee lake, which is 500 feet above the sea, beds of stratified clay are often found underlain and overlain by till. The clay is free from pebbles, and well suited for brick-making. It varies from five or ten to thirty feet in thickness, and occurs at various heights from the level of the lake to three hundred feet above it. The overlying till is from two or three to ten or fifteen feet in thickness, wholly unstratified and very coarse, containing numerous boulders, which may be five or six feet in diameter. These remarkable clay beds were probably deposited, where drainage was obstructed, in hollows melted under the margin of the departing ice-sheet. This lake basin lies at the south side of the White Mountains, from which source we might expect a greater depth of ice to move southward and

cover its area near the close of the glacial period than would at that time remain in other parts of the State to the east and west. The ice-sheet probably formed a high mountain-like ridge over this lake, after it had disappeared from the basin of Ossipee lake and from the lower part of the Merrimack valley. The ice current was thus changed in direction on the east side of Winnipiseogee lake, and the last striæ marked on the ledges differ much from the prevailing course, being deflected towards the east, or even to the north of east. As the melting continued, drainage was frequently obstructed, because the ice-sheet retreated from the lines of watershed towards the middle of this hydrographic basin. The water seems then to have melted large open spaces beneath the ice, near its margin, in which beds of clay and sand were deposited. This would occur at the various heights and in the situations where these beds are found, and the till which overlies them is shown by its material to be that which was contained in the ice-sheet, and fell upon the surface when its melting was completed.

Near the coast, beds of fine gravel, sand, or clay, sometimes enclosing marine shells, are in several instances overlain by upper till, giving evidence of a retreat and subsequent advance of the ice-sheet. Doubtless the ice resisted the influence of the warmer climate and changed conditions before which it disappeared, continuing late like the snow in spring. Its departure at the last was correspondingly rapid, and was closely followed by the hardier forms of vegetable and animal life.

The abundant deposition of drift, both stratified and unstratified, which took place during the final melting of the ice-sheet, has been brought into due prominence by Prof. James D. Dana, who denominates this the *Champlain period*, deriving the name from the marine beds of this era, which occur on the borders of Lake Champlain. It is probable that this final melting took place mostly upon the surface, which was thus moulded into basins and valleys; and near the terminal front of the ice, these appear to have coincided closely with the contour of the land. At last the surface of the ice became covered with the abraded material which had been contained in its mass, and which was now exposed to the washing of its innumerable streams. Its finer portions would be commonly carried away; and the strong current of the rivers which would be formed near the end of the ice-sheet could transport coarse gravel, or even boulders of con-

siderable size. When the glacial river entered the open valley from which the ice had retreated, or in the lower part of its channel, while still walled on both sides by ice, its current was slackened by the less rapid descent, causing the deposition, first of its coarsest gravel, and afterwards, in succession, of its finer gravel, sand, and fine silt or clay. The valleys were thus filled with extensive and thick deposits of modified drift, which took the same slope with the descending current, and which increased in depth in the same way that additions are now made to the bottom-lands of our large rivers by the annual floods of spring.

The retreat of the ice sheet was towards the north; and wherever the natural drainage was in that direction, it would be for a time obstructed by the ice, forming lakes in which the deposition of modified drift would be much different from that which took place when the slope was to the south. In New Hampshire the portion of the Contoocook valley which extends through Hillsborough county was occupied by a lake during a large portion of the Champlain period.

The oldest of our deposits of modified drift are long ridges or intermixed short ridges and mounds, composed of very coarse water-worn gravel, or of alternate layers of gravel and sand irregularly bedded, a section of which shows an arched or anticlinal stratification. Wherever the ordinary fine alluvium also occurs, it overlies, or in part covers, these deposits. Similar ridges of gravel have been often described by European geologists, under the various names of *kames* in Scotland, *eskers* in Ireland, and *asar* in Sweden. They have also been described by geologists in many portions of the northern United States and Canada. In New Hampshire kames are of frequent occurrence, sometimes a single one extending in a steep, narrow ridge for miles along the lowest portion of a valley, or elsewhere short, and several parallel to each other, or in very irregular mounds and ridges, with hollows enclosing small ponds. Their position is generally along the middle or lowest part of the valleys, which are bordered by high ranges of hills; but in the south-east part of the State, in some parts of Maine, and in Eastern Massachusetts, where there are only scattered hills, with the valleys not much below the general level of the country, these ridges, of smaller size than in the great valleys, are found extending usually north and south, without special regard to the present water-courses. In the valleys of our largest rivers, the Connecticut and Merrimack, they

extend long distances, but have heretofore escaped notice, owing to the large amount of levelly stratified drift, forming the conspicuous terraces and plains by which the underlying kames are often nearly concealed.

The origin of the kames has been a question much discussed by European geologists, and the theory commonly accepted on both sides of the Atlantic was, that they were heaped up in these peculiar ridges and mounds through the agency of marine currents during a submergence of the land. Even if such ridges could be formed by this cause, under any circumstances, it seemed impossible to account thus for the kames in the Connecticut and Merrimack valleys, which, being bordered on both sides by high hills, would have been long estuaries, opened to the sea only at their mouths, and therefore not affected by oceanic currents. From the position of these peculiar accumulations of gravel, which are overlain by the horizontally stratified drift, the date of their formation is known to be between the period when the ice-sheet moved over the land and that closely following, in which this more recent stratified drift was deposited in the open valley from the floods that were supplied by the melting ice. We are thus led to an explanation of the kames, which seems to be supported by all the facts observed in New Hampshire, and which appears to apply, also, to the similar deposits which have been described in other parts of the United States and in Europe. During the melting of the ice-sheet, it became moulded upon the surface, by this process of destruction, into great basins and valleys; and at the last, the avenues by which its melting waters escaped came gradually to coincide with the depressions of the land. As the melted area slowly extended into the continental glacier, its vast floods found their outlet at the head of the advancing valley. This often took place by a single channel, bordered by ice walls, as was the case along the whole Connecticut kame; but in the Merrimack valley, and in eastern New Hampshire and Massachusetts, these glacial rivers also frequently had their mouth by numerous channels, which were separated by ridges of ice. In these channels were deposited materials gathered by the streams from the melting glacier. By the low water of winter layers of sand would be formed, and the strong currents of summer, layers of gravel, often very coarse, which would be very irregularly bedded, here sand, and there gravel accumulating, and without

much order interstratified with each other. Sometimes the melting may have been so rapid that the entire section of a kame may show only the deposition of a single summer, which would then be very coarse gravel, without layers of sand. When the bordering and separating ice walls disappeared, these deposits remained in the long ridges of the kames, with steep slopes and irregularly arched statification. Very irregular, short ridges, mounds, and enclosed hollows resulted from deposition among irregular masses of ice.

The glacial rivers which we have described appear to have flowed in channels upon the surface of the ice, and the formation of the kames took place at or near their mouths, extending along the valley as fast as the ice-front retreated. Large angular boulders are sometimes, but not frequently, found in the kames or upon their surface. Their rare occurrence forbids the supposition that these deposits were formed in channels beneath the ice-sheet, from which many such blocks would have fallen upon the kames.

The course of the glacial river of Connecticut valley for a distance of twenty-four miles is marked by a single continuous kame, frequently nearly covered by the alluvium of the highest terraces, extending from Lyme, New Hampshire, to Windsor, Vermont. Its height is 150 to 250 feet above the river, by which it has been frequently cut through, as well as by tributary streams. This ridge occupies nearly the middle of the valley, and as the river has cut its channel through the alluvium, this has been often a barrier, rising steeply upon one side and protecting the plains behind it. In one or two placces it has been swept away by the river for a distance of one half mile to one mile, and below these places the terraces show, by their coarseness, that the kame has supplied a portion of their material. Short remnants of similar form and material occur northward at Wells River and Colebrook, the last at an altitude of 1,050 feet above the sea; and southward at Charlestown, Bellows Falls, Dummerston, and Brattleborough. The kame of Connecticut valley is principally gravel, always water-worn, the largest pebbles being one to two feet in diameter, with frequent layers, one or two feet in thickness, of coarse, sharp sand.

In the Merrimack valley, a series of kames, always in ridges, sometimes a single one, but more often with irregular branches or several parellel to each other, extends from Loudon, along

Soucook river and the west side of Merrimack river, to Manchester, a distance of twenty miles. Their height varies from 60 to 125 feet above the river, and they are often nearly covered by the alluvium. Those ridges are coarser than the kame of Connecticut valley, consisting almost wholly of very coarse water-worn gravel, with the largest rocks three to four feet in diameter, and containing fewer and only thin layers of sand.

Another interesting series of kames extends from Saco river to Six mile pond, and from Ossipee lake, south-easterly, along Pine river, and by Pine River and Balch ponds into Maine. The first description of any of these ridges in America appears to have been given by Dr. Edward Hitchcock, in 1842, respecting a series which is well shown in Lawrence and Andover, Massachusetts. This series was at first supposed to be about one and a half miles in length ; but Rev. George F. Wright has recently traced it more than twenty-five miles.

About Dover, and southward, near the sea coast, thick deposits of gravel and sand, sometimes forming extensive plains, are found occupying areas of watershed from one hundred to two hundred feet above the streams, which often flow in wide valleys that are nearly destitute of modified drift. The absence in the valleys of the terraces which mark erosion through modified drift, shows that they were never filled with the same materials, and that these remarkable plains and ridges were deposited in their present isolated position, with wide areas of lower land at each side. How this took place we can only explain by referring the formation of these deposits to the same causes which produced the kames. The ice-sheet still remained unmelted upon each side at the time of their deposition, filling the valleys and wide areas of low land, over which this gravel and sand must otherwise have been spread by the current of the floods on which they were brought. The most extensive of these plains occur about Willand and Barbadoes ponds, near Dover, and in Newington and the north-west part of Portsmouth. Broadly rounded deposits of the same class form the elevations on which the villages of Rye, North Hampton, and Hampton are built. A very interesting ridge of this kind extends from north-west to south-east through the city of Newburyport, Massachusetts.

The extensive level plains and high terraces which border the rivers of New Hampshire, constituting the most conspicuous and by far the largest portion of our modified drift, were also deposited

in the Champlain period. The departing ice-sheet was the principal source both of the vast amount of material and of water for transporting it into the valleys, which appear in most cases to have been filled to the level of the highest terraces or plains. The prevailing horizontal stratification of these deposits show that they were spread over large areas by the current of the floods which held them in suspension. The modified drift thus increased in depth in the principal valleys through a long period, which may have continued until the last of the ice at the head of the valley and of its tributaries had disappeared.

During the *recent or terrace period*, the rivers have been at work, excavating deep and wide channels in this alluvium. The terraces mark heights at which, in this work of erosion, they have left portions of their successive flood plains. As soon as the supply of material became insufficient to fill the place of that excavated by the river, a deep channel was gradually formed in the broad flood-plain. The process was very slow, allowing the river to continue for a long time at nearly the same level, undermining and wearing away its bank on one side, and depositing the material on the opposite side, till a wide and nearly level lower flood-plain would be formed, bordered on both sides by steep terraces. When the current became turned, to wear away the bank in the opposite direction, a large portion of this new flood-plain would be undermined and re-deposited at a lower level ; but the direction of the current's wear might be again reversed in season to leave a narrow strip, which would then form a lower terrace. In this way we often see the highest plain on our large rivers, and the lower terraces very frequently, being now undermined by the wear of the current, forming steep bluffs and banks. The fine character of the materials which compose the lowest terraces and the interval, or present flood plain, is due to this wearing away and re-deposition by the river, which have been many times repeated, till what may have been at first gravel becomes very fine sand or silt.

Neither the deposition nor terracing of the modified drift requires any submergence, as by lakes or the sea. These deposits have the form which they must naturally take, in being rapidly brought into the valley by floods, and in afterward being partly excavated by rivers in the process of deepening their channels.

Along Connecticut river, for a distance of 120 miles south from Fifteen-miles falls, and thence extending south into Massa

chusetts, the terraces are very numerous, frequently four or five on a side, and reaching a height of 100 to 200 feet above the stream. In the upper Connecticut valley and along Merrimack river, the alluvium principally consists of the bottom-land or interval, and the high terrace or plain, which averages about 100 feet above the river. Both the terraces and intervals have a slight descent with the valley, that of the highest terrace showing frequently a very regular slope. On the Connecticut river above Fifteen-miles falls, the upper terrace descends with the valley in forty-five miles from 1,100 to 850 feet above the sea, averaging $5\frac{1}{2}$ feet to a mile. For 120 miles south from these falls to Massachusetts line, the slope is less steep and less regular, desceending from 650 to 350 feet above the sea. On the Pemigewasset and Merrimack rivers, for ninety-six miles, this slope of the highest terrace varies from 15 to 5 feet in a mile, descending from 750 to 160 feet above the sea.

Upon entering the large valleys, tributary streams of comparatively narrow channel and rapid descent frequently formed extensive deposits, in the Champlain period, similar in material to the flood-plain of the main valley, but having a greater height. Sometimes upon Connecticut river these deltas, being partially undermined, form conspicuous terraces a hundred feet above the highest normal terrace, which is the remnant of the river's continuous flood-plain.

Before the thick forest, natural to all parts of the State, had sprung up, the strong north-west winds were in many places sweeping the loose sand from the valleys upward along the hillsides. These sand-drifts or dunes are found at heights varying from the level of the highest terrace to two hundred feet above it, along the east side of Connecticut and Merrimack valleys and south-east of Ossipee lake. With the clearing away of the forest, they have become again drifted by the wind.

The greatest widths of modified drift that can be measured in the Connecticut valley, on the west side of New Hampshire, are in Haverhill and Newbury, two miles, and in Hinsdale and Vernon, two and a half miles wide. The average width is fully one mile. The most extensive bottom-lands on this river are the Upper Coös intervals at Lancaster, and between Wells River and Bradford, Vt., the latter being twelve miles long, and one-half to one mile wide, including the Lower Coös intervals of Newbury, Haverhill, and Piermont. The largest plains are expanses

of the upper terrace, or of still higher tributary deltas. These areas are generally of a clayey, moist, productive soil, quite in contrast with the dry and sandy "pine-plains" of Merrimack river, Ossipee lake, and other parts of the State. The modified drift of the Merrimack is usually one to two miles wide; its greatest development is in Concord, and in Litchfield and Merrimack, where it has a width of nearly four miles.

Valuable beds of clay, extensively used for brick-making, occur in the highest terrace on the east side of Merrimack river for four miles north from Hooksett. This clay appears to form a nearly continuous stratum, which has a thickness of from 20 to 30 feet, with its top about 100 feet above the river, or 300 feet above the sea. It is overlain by a few feet of sand. The upper part of this stratum consists of a hard and compact *gray clay*. At a depth of 12 to 15 feet, this is usually separated at a definite line from the underlying *blue clay*, which is soft and plastic when dug from the bank. Deposits of the same gray and blue clay, the latter always below the former, are frequently found in the south-east part of the State, near the coast, and along Hudson river and Lake Champlain. These clays and the overlying sand are probably equivalent to the *Leda clay* and the *Saxicava* sand, distinguished by Principal Dawson in the St. Lawrence valley.

The only marine shells that have been found in New Hampshire, occur in these beds near the coast, and show that the sea stood at least 150 feet higher than now during the deposition of the modified drift. Bones of a seal and shells of *Leda truncata* are found at South Berwick, Maine, 30 feet below the surface, and nearly 100 feet above the sea. The surface here is a few feet of sand, the whole depth below which is clay, the upper portion gray, and the lower blue. *Saxicava rugosa*, *Mytilus edulis*, and *Astarte castanea* occur atseveral places in Kittery, Maine, within 30 feet above the sea. These towns border New Hampshire. The most southern locality at which *Leda truncata* has been found is Portsmouth, New Hampshire, where it occnrs 15 feet below the surface, and 30 feet above high tide, in blue plastic clay- This species is now restricted to arctic seas, and its occurrence in Portsmouth and South Berwick shows that an arctic climate prevailed during the deposition of the beds in which it is found; but the presence of *Astarte castanea* at Kittery is proof that the ocean became nearly as warm as now before it sank to its present level.

LOWER CARBONIFEROUS FISHES OF NEW BRUNSWICK.

By Principal Dawson, LL.D., F.R.S.

The recent sinking of a shaft on the property of the Beliveau Albertite and Oil Company on the Petitcodiac River, has exposed a new and interesting deposit of fossil fishes in the rich bituminous shales of that district, which contain the remarkable deposits of Albertite, described in my Acadian Geology, second edition, p. 231 *et seq*. The bed affording these fossils is a dark brown bituminous shale; and I am informed by Mr. E. B. Chandler, to whom I am indebted for an interesting collection of the fish remains, was from four to five feet thick. The specimens thus presented, with those previously in my collection, and one kindly given to me by Mr. F. Adams, of this University, and the valuable memoirs recently published by Dr. Newberry in the Ohio Reports, and by Dr. Traquair in the Journal of the Geological Society, enable me now to give a revision of the fishes of this locality, as described by Dr. Jackson in his Report of 1851 on the Albert mine, which I was unable to do in the second edition of Acadian Geology, owing to the small number of specimens to which at that time I had access.

In the collections in my possession, I recognize, in all, five species, three of them very small, and two of larger size. Of these, one, which is unusually well preserved and is the smallest of the whole, appears to be new, and I shall begin by describing it.

Palæoniscus (*Rhadinichthys*) *Modulus*, n. s.—Length, five to six centimetres; greatest breadth, 15 to 17 millimetres—the proportion of length to breadth being about five to one and a half. Head, oval and obtuse; details not preserved, except that the bones are sculptured with fine waving lines. Body gracefully curved, and upper lobe of tail long and slender. Pectoral fins small, with stout, unjointed rays. Ventral not distinctly preserved, but apparently small and nearer to pectorals than to anal. Dorsal and anal of moderate size and opposite each other. Caudal very heterocercal, with the lower lobe sharply pointed. Fins with well developed fulcral spines, especially large at the base of the caudal. Scales of the sides rhombic, coarsely toothed on the posterior edges and elaborately sculptured with flat, scaly ridges,

corresponding to the teeth of the edge. The ridges are arranged in an upper and lower series, the latter oblique to the former, so that each scale has the appearance of being composed of two distinct portions. Lower surface of scales smooth, with a few furrows corresponding to the ridges above, and the posterior edges similarly serrate. Caudal scales narrowly rhombic, pointed, and with a few central lines. The back is protected with about ten large oval scales between the head and the dorsal. They are sculptured with waving lines, curving with the edges, and are apparently truncate and serrate behind. The fish figured by Jackson, Pl. II, Fig. 5, but not named, probably belongs to the above species.

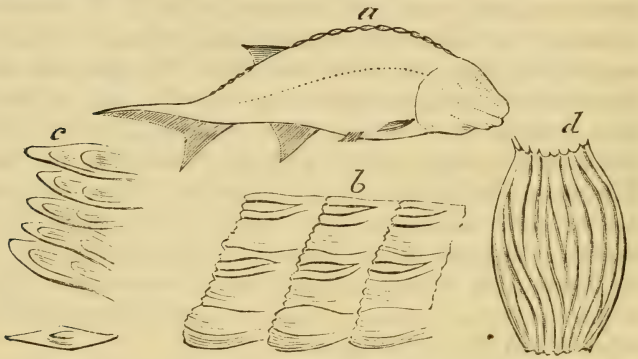

Fig. *Palæoniscus Modulus*, N. S.

(*a*) Outline, natural size.
(*b*) Series of Scales enlarged, seen from inside. The lower row are those on mesial line.
(*c*) Surface of exposed part of scale from side and upper lobe of tail, showing sculpture, enlarged.
(*d*) One of the dorsal scales, enlarged.

This beautiful and elaborately ornamented little fish is a perfect model in miniature of that type of lower carboniferous Palæoniscids to which it belongs, and which has recently been separated by Dr. Traquair in the genus or subgenus Rhadinichthys. For this reason, I have given it the specific name *modulus*. To the same genus belong the two next species, described by Jackson, of which I shall give merely distinctive marks.

P. Alberti, Jackson, is larger than the preceding. The scales have more numerous striæ. The dorsal scales are rounded pos-

teriorly. The posterior edge of the anal fin approaches nearly to the caudal, and extends considerably behind the posterior edge of the dorsal.

P. Cairnsii, Jackson.—About the same size with the last, but more slender, and the head less obtuse in front. Scales think and with few striæ, and less numerous serrations. Dorsal scales pointed posteriorly. Anal fin somewhat remote from caudal and opposite dorsal.

A specimen collected by Mr. Ells, of the Geological Survey, indicates a fish of the same general form with *P. Alberti*, but about six inches long. The outline of this fish is well seen, but the details are not sufficiently clear to show if it differs in these from the smaller species.

The next species and perhaps the following one, belong to the genus *Elonichthys* of Giebel. They are much larger than the preceding.

P. Brownii, Jackson, is deep in form, with large dorsal and anal, the latter reaching almost to base of caudal. Scales of body broad and with numerous fine horizontal striato-punctate furrows, which turn abruptly upward at the anterior side of each scale. A nearly perfect specimen, collected by Mr. Ells, shows that the head was of moderate size, and the body about ten inches long and three and a quarter inches wide, the breadth at the dorsal fin being as great as at the shoulders, giving a sort of rectangular form to the fish, whose breadth suddenly diminishes toward the tail.

The crystalline lens of the eye of Mr. Ells's specimen is preserved in calcite. Under the microscope it shows concentric laminæ and coarse bands or rods with indistinct denticulations; the structure being similar to that in the crystalline lens of the modern ganoid *Amia ocellicauda*. This is the first instance known to me of the preservation of the structure of the crystalline lens in a palæozoic fish.

P. Jacksoni, N. S.—A species figured, but not described, by Jackson, is represented by many fragments in my collection. It is the largest of these fishes, reaching a length of 15 inches. It may be distinguished from the last by its more slender form, its small anal fin, more remote from the caudal, and by the character of the scales, which have many horizontal striæ, and have in the broader ones a few deep and strong serrations posteriorly.

The whole of these fishes have been preserved entire, the body being perfectly flattened and thrown into attitudes which imply that they were imbedded when living or immediately after death. The material in which they are contained is shown, by its microscopical and chemical characters, to have been a vegetable muck or mud, and the fish were either overwhelmed by it in the manner of a bursting bog, or were stifled by the non-oxygenated water mixed with this mud, and suddenly killed and imbedded in the accumulating sediment. That they occur in this perfect state and in a limited thickness of the deposit, may imply that at certain times they were overwhelmed by the irruption of this fetid organic mud into the water in which they lived. The bed is low down in the Lower Carboniferous series, being the equivalent of the Horton series of Nova Scotia; so that these fishes are among the oldest that we know in the Carboniferous period; but we know, from the Horton beds, that many far larger and predaceous ganoids were their contemporaries. No remains of these have however as yet been found in the Albert or Beliveau beds, which were probably deposited in limited fresh-water basins, perhaps not ordinarily accessible to the larger fishes.

Sir Philip Egerton* and Dr. Traquair† have both remarked on the similarity of these fishes to those found in the Lower Carboniferous of Scotland, and Dr. Newberry has described very similar species from the Carboniferous of Illinois and Ohio.‡

NOTE ON A FOSSIL SEAL FROM THE LEDA CLAY OF THE OTTAWA VALLEY.

By Principal Dawson, LL.D., F.R.S.

Read before the Natural History Society, Oct. 29, 1277.

This interesting geological specimen was kindly sent to me, for inspection, by Dr. Grant, of Ottawa. It has an historical as well as scientific interest, which bridges over not the whole history of our Society, but that of its publication, *The Canadian Naturalist*. About twenty years ago, Mr. Billings, then at

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* Journal of Geological Society, 1853.

† *ib.* 1877.

‡ Report on Illinois, Vol. II; Palæontology of Ohio, Vol. I.

Ottawa, obtained a nodule with certain bones enclosed in it from the Post-pliocene clays of Green's Creek, on the Ottawa, which have offered so many beautiful specimens of the Capelin and other fishes, and also of marine shells of northern and cold water types. Mr. Billings regarded the bones as those of the limbs of "a small animal of aquatic habit," but, not being able to determine the species, sent the specimen to Dr. Leidy, of Philadelphia. He recognized the bones as those of the hinder extremity of a young seal, but of what species was uncertain. A good figuure and description were published in the first volume of the *Naturalist* in 1856. No further information bearing directly on this fossil was secured until the present year, when the bone now exhibited was obtained by Dr. Grant from a boy who had collected it at the same place and in the same bed in which the first mentioned specimen was found. It is the left ramus of the lower jaw of a young seal, containing a canine and four molar teeth, with an impression of the fifth. It enables us now to affirm that the species is *Phoca Groenlandica*—(*Pagophilus Groenlandicus* of Gray's Catalogue) the common Greenland seal, and it is of such size that it may have belonged to the same individual which furnished the bones described in 1856, or at least to an animal of the same species and of similar age.

Skeletons of larger individuals of this species, which still lives in the Gulf of St. Lawrence, have been found in the Post-pliocene clays near Montreal. Portions of them may be seen in the museums of the Geological Survey and of the University.

This specimen thus carries us back to that glacial period when the valleys of the St. Lawrence and the Ottawa were occupied with the cold ice-laden waters of the Arctic Sea, furnishing a fit habitat for the Greenland seal and the fishes which are its food. It also shows how one discovery in geology serves to throw light upon another, and how our knowledge grows little by little in the lapse of years; and it indicates the value of a society like this, in treasuring up the little instalments of facts accruing from time to time, and so building up the knowledge of the natural history of our country.

The fossil fishes found in the nodules of the clay at Green's Creek, and catalogued in my notes on the Post-pliocene of Canada are, *Mallotus Villosus*, the capelin, *Cyclopterus lumpus*, the lump-sucker, and a species of *Gasterosteus*. I have also fragments that seem to indicate a small *Cottus*.

THE EARTHQUAKE OF NOVEMBER 4, 1877.

(Read at the November Meeting of the Natural History Society, by Principal Dawson, LL.D., F.R.S.)

In the *Canadian Naturalist*, Vol. V., first series, will be found notes on the earthquake of October 17, 1860, with a summary of facts relating to the previous shocks recorded in Canada, and some general remarks on their periods, local peculiarities and probable causes. The subject was continued in Vol. 1. of the new series, in connection with the earthquake of April, 1864, and in Vol. V., new series, in connection with that of October 20th, 1870. I may refer to these notices for what is known on Canadian earthquakes up to that time, and we may now continue the narrative in connection with the somewhat wide-spread disturbances of the earth's crust in the present autumn.

On January 4th, 1871, a shock was experienced at Hawkesbury, Ontario, but was not reported from any other place. A more extensive earthquake occurred on May 22nd, 1871. It prevailed from the city of Quebec to the western part of Ontario. The time for Quebec is stated at ten minutes before two a. m., and there was a second shock at twenty minutes past three. The time for Perth, Ontario, is stated at half-past one. It is noteworthy that this earthquake occurred at nearly the same time with that recently experienced. Since 1871 several minor shocks have been noticed from time to time, but did not attract much attention, and I have preserved no details in relation to them.

That of the present month was probably the most considerable since 1871. It occurred at Montreal, at ten minutes before two on the morning of Sunday, November 4th. At Montreal there was only one distinct shock, preceded by the usual rumbling noise, and sufficiently severe to be distinctly felt, and to shake window-sashes and other loose objects, causing them to vibrate for several seconds. In so far as the published reports give information, the shock would seem to have been limited to the area along the river St. Lawrence, extending from near Three Rivers on the east, to Kingston on the west, and in a direction transverse to the St. Lawrence from Ottawa to the southern part of New England. In a paper prepared for the American Journal of

Science, by Professor Rockwood, of Princeton, he defines the area in question as that of "an irregular trapezium whose angles are marked by Pembroke, Ont., Three Rivers, P.Q., Hartford, Conn., and Auburn, N. Y., and which is some 200 miles on its northern and southern sides, about 300 miles on the eastern side, and 175 on the western." So far as can be learned from the reports, the shock seems to have been most severely felt on the north side of the valley of the St. Lawrence and about Lake Champlain, or may be said to have had its centre in the Adirondack and Green Mountain region.

In the notice of Canadian earthquakes in 1860, I mentioned that it had been observed that the greatest and most frequent shocks have occurred a little after the middle and toward the close of each century. We are now approaching the latter period, so that possibly the last shock may be the beginning of a series of similar phenomena. Since, however, there is no known reason for this periodicity, it may be a merely accidental coincidence, or may depend on some cycle of about half a century.

If we add to the table of earthquakes in Eastern America, given in Vol. V. of the *Naturalist*, the more recent earthquakes observed in Canada, the proportion for the several months will stand as follows:—

January, 9 earthquakes; February, 4; March, 5; April, 5; May, 7; June, 3; July, 4; August, 6; September, 4; October, 8; November, 15; December, 8. Total, 78.

Thus of seventy-eight recorded Canadian and New England earthquakes, fifteen, or nearly one-fifth, occcured in November; forty, or more than half of the total number, in the third of the year, extending from October to January inclusive. The published catalogues show that similar ratios have been observed elsewhere, at least in the Northern hemisphere.

In some earthquakes a low state of the barometer has been observed, as if a diminution of atmospheric pressure was connected with the movements of the crust producing seismic vibrations. This we can readily understand if a low state of the barometer should prevail over an area of the crust tending to rise, simultaneously with a high pressure over a sinking area. In this case a state of previous tension might terminate in a rent of the crust causing vibration. In the present case no very decided indication of such a cause appears, at least in so far as this part

of the St Lawrence valley is concerned. Mr. McLeod informs me that the mean barometer for the week preceding the earthquake was 29.7564, and for the following week 30.0864. The barometer on the Friday before the earthquake at 8 p. m. was 29.115, the lowest observed since March last; but at 1.50 a. m. on Saturday it was about 29.967, which is very near the mean of November 1876, and also a little above the mean barometer of the place for the whole year; and on Sunday afternoon it rose to 30.200. It would thus appear that the earthquake was preceded by a low state of the barometer, and followed by one unusually high for the season, and this rapid fluctuation was accompanied with much atmospheric disturbance in the region of the Lakes and the St. Lawrence Valley. The weather map issued by the War Department at Washington for Sunday morning, November 4th, shows a low barometer in the Gulf of St. Lawrence and a high barometer in the Middle States—the area of the earthquake being about half way between the extremes.

In connection with previous earthquakes it has been observed that the greatest intensity of the shocks appeared near the junction of the Laurentian with the Silurian formations. This would be a natural consequence either of the propagation of vibrations upwards from deep underlying regions through the Laurentian rocks, or from the overlying sedimentary rocks towards these older rocks. In the case of the recent earthquake, this appears to have applied chiefly to the border of the Laurentians extending round by the Ottawa and Kingston to the Adirondacks, as if a wave propagated through the Silurian formations had broken against the southern and eastern sides of the Laurentian region, or a shock originating under the Laurentian of these regions had extended itself from them into the Silurian rocks to the south and east. If the prevailing impression stated in the reports, that the vibrations passed from W. to E. or N.W to S.E., is correct, the latter would be the more probable supposition. It is, however, very difficult to attain to any certainty as to the actual direction of the disturbance, and some observers give it as precisely the opposite of that above stated.

In the present year there have been violent earthquake shocks along the chain of the Andes. The latest of these heard of was that of Lima and Callao on the 9th of October. On the west coast of North America, portions of Oregon and Washington

Territories were shaken on the 12th October. On the 14th November a slight shock was felt at Cornwall, Ontario, and on the 15th November earthquake shocks occurred over a wide area in Kansas, Iowa, Dakota and Nebraska.

While the above was in press the following appeared in the daily newspapers:—

"A despatch from Beachburg says:—Two shocks of earthquake were felt here this morning (Dec. 18), the first being between the hours of one and two, and the last between five and six o'clock, the latter being so severe as to shake houses and arouse the inmates from their slumbers."

Beachburg is on the south side of the Ottawa, about twelve miles north-west of Portage du Fort.

ON THE FORMATION OF METALLIC VEINS.

By Fridolin Sandberger.

(Translated from "Die B. & H. Maennische Zeitung," of 2nd and 9th November, 1877.)

Observations on metallic veins and their relations to the country-rock that I have carried on for many years in the Rhenish slate plateau, and in the primordial plateau of the Black Forest, urged me on to researches into the elementary components of the so-called vein-stones, and also of the heavy and precious metals that occur in metallic veins in the form of sulphuric, arsenical and antimonial compounds. These researches, although far from finished yet, have, as I believe, already yielded a number of facts of general interest, which may possibly stimulate others to farther pursuit of the subject. I thought that I should seek the elementary components in the first-formed silicates, which are among the most important ingredients of the oldest crystalline granular and schistose rocks of the gneissose and granitic classes, as also of the eruptive rocks of all geologic ages.

In the first place, I was occupied with the question of the origin of the barium sulphate or heavy-spar, which I had propounded to myself as long ago as 1858. At that time I had always found baryta in a number of the great (Carlsbad) twin-crystals of orthoclase out of the porphyritic granite in the neigh-

bourhood of Achern and Offenburg, but sometimes only in too small a quantity to determine quantitatively. In the crystals of the same rock from Carlsbad there is, according to Redner, only about half a per cent. (0.48 along with 2.41 Na_2O and 15.67 K_2O)*. The orthoclase, rich in potash, of this rock is known to weather but very slowly; as the crystals, loose and comparatively but slightly weathered, can in many places he picked out of the grit into which the rock has crumbled. The baryta separates out only when the crystals are much decomposed, and this seems to take place to any considerable extent only locally. To this corresponds the variety and narrowness of the veins of baryta in the region of porphyritic granite from Achern to the Kinzigthal, where such are observed only on the high Horn near Zell, by Schloss Staufenberg (7 cm), on the Lautenbaechle in the Durbachthal ($2\frac{1}{2}$ cm). Others near Gemsbach in the Murgthal exhibit slighter dimensions. The only ores observed in them were spathic iron and a poor limonite.

Otherwise is the behaviour of the non-porphyritic granite that extends from Rippoldsau along the eastern side of the chief gneiss zone of the Black Forest past Schapbach, Wittichen, Alpirsbach, Schiltach, Hornberg and Tryberg towards St. Blasien. In the northern part of this region the orthoclase is poorer in potash (7.81 per cent.) but richer in soda (3.24 per cent.) and contains along with 0.58 lime 0.22 per cent. baryta.† It weathers a good deal more readily than that of the porphyritic granite, probably on account of its greater per centage of lime and soda. Wherever the feldspar is mostly converted into pinite and the rock is much loosened it is traversed by innumerable barytes and metallic veins, which terminate abruptly wherever the fresh granite replaces this porous rock. The veins consist merely of a series of stringers, which quickly unite and attain a width of half an inch to ten inches at the most, only to separate again. Only towards the boundaries of the gneiss, for instance, in the Tiefenbachthal, near Schapbach, does this behaviour change, and the veins become far wider up to five feet; but with merely traces of cobalt *fahlerz*. Only

* The entire composition of the feldspar is: SiO_2 63.02, Al_2O_3 18.28, Mg O 0.14, Ba O 0.48, Na_2O 2.41, K_2O 15.67.

† Its entire composition, according to Nessler is: SiO_2 65.59, Al_2O_3 20.53, Mg O 0.44, Ca O 0.58, Ba O 0.22, Na_2O 3.24, K_2O 7.81.

their great local richness in silver and cobalt (to which farther reference shall be made) rendered them worth mining near Wittichen, and gave to them a high value. These veins could never have been worked for heavyspar, as this is always coloured flesh-red (and even brick-red in some places) by finely-divided scales of red hematite.

These analyses of the fresh granite by Nessler *a* and of the decomposed by Petersen *b*.

	a Schapbach,	*b* Wittichen (calculated free from water)		
SiO_2	67.59	70.25	+	2.66
Al_2O_3	18.13	19.18	+	1.05
Fe_2O_3	3.45	2.84	—	0.61
CaO	1.58	0.32	—	1.26
BaO	Trace	0.17	+	0.17
K_2O	5.38	5.22	—	0.16
N_2O	2.23	0.65	—	0.58
MgO	1.65	0.37	—	1.28

prove that the baryta still withstands the attack of waters impregnated with carbonic acid, when no inconsiderable portions of sodic carbonate, potash, lime, magnesia and ferrous oxide have been already carried off. The baryta is therefore not the oldest vein-stone of the Wittichen veins, but is sometimes underlaid by carbonates. The circumstance that it completely coats and covers the older native silver sheds clear light upon its mode of formation, therefore it was in solution as baric sulphate and not as baric sulphide, which cannot be so easily proved in any other place. Since I could extract soluble sulphates (alkalies) from many granites by means of water, the baric carbonate formed by the active decomposition of the feldspar must certainly have come into contact with them in that form and been precipitated. That it can remain partly in solution along with much alkaline carbonates in waters flowing from the granite is proved by the analyses of the Baden mineral waters springing from similar granite, in which Bunsen has found it along with strontic sulphate. The deposition of crystalline baric sulphate in one of the canals of the Carlsbad wells is known.

The orthoclase of the gneiss is the most easily attacked, as it occurs in the larger (Carlsbad) twin-crystals in the porphyritic varieties and the larger granitic bands in the region of the Renchthal, Wolfthal and Kinzigthal. An analysis of the mineral from

Wildschapbach yielded: SiO_2 63.10, Al_2O_3 20.83, MgO 0.52, CaO 2.01, BaO 0,81, Na_2O 9.22, K_2O 2.92.

As the feldspar, in consequence of its greater percentage of lime and soda, weathers far more readily than the orthoclase of the granite and moreover contains more baryta, it might certainly be expected that the largest veins of baryta would occur in the gneiss; which is the case. Thus the vein on the Schottenhoefen near Zell on the Harmersbach reaches a thickness of 25 feet, and the chief vein of the Clara Mine in the Hinterrankach near Schapbach one of forty feet. Heavyspar has played an important part also in the celebrated Wenzel vein near Wittichen. In the Friedrich-Christian and Neu Herrensegen veins in Wildschapbach, which traverse granularly-banded gneiss rich in the above-mentioned orthoclase, only a small part of their contents still consist of heavyspar; although its former abundant distribution in the vein is proved by the structure of the quartz masses that carry the predominating ore (galena) and have without exception retained the form of the vanished heavyspar. This substitution seems to have occurred only where the feldspar of the country rock has been completely changed to kaolin, *i. e.* has been deprived of all its bases except alumina. Since considerable quantities of silicic acid were separated out in this process, as is proved by the following analyses:

	Sodium-orthoclase from Wildschapbach, containing baryta.	Kaolin, according to Forchhammer, calculated free from water.		
SiO_2	63.10	54.52	—	8.58
Al_2O_3	20.83	45.48	+	24.65
CaO	2.01	0.00	—	2.01
BaO	0.81	0.00	—	0.81
MgO	0.52	0.00	—	0.52
Na_2O	9.22	0.00	—	9.22
K_2O	2.92	0.00	—	2.92

the replacement of the heavyspar is intelligible that has occurred in all cases where the country-rock has not reached the utmost limits of decomposition. In the gneiss there is no lack of sulphates to precipitate the baric carbonate as heavyspar. Apart from my direct solution-experiments, which regularly yielded scuh, Bunsen's analyses of the springs of Griesbach, Freiersbach, Petersthal and Antogast, which do not come from metallic veins, as do those of Rippoldsau, but directly from the gneiss,

show very considerable quantities of sodic and potassic sulphate. Whence the sulphates are derived, whether they should be sought for in the numerous fluid-filled cavities of the quartz or where else, has not yet been determined. The southern part of the Black Forest is also rich in veins of baryta; but the feldspars of the local gneisses and granites have not yet been examined for baryta. Therefore the discussion of them must be postponed.

The extremely rare occurrence of heavyspar in the geodes of the phonolite of Oberschaffhausen in the Kaiserstuhl is very easily explained. The presence of baryta, which A. Mitscherlich observed in many sanidines, occurs also in this rock and the decomposed nosean furnishes sulphates in sufficient quantity. Therefore it cannot be wondered at that already in 1829 O. Eisenlohr observed on mesotype wine-yellow heavyspars an inch in size, and Schill repeats this observation. The small quantity of heavyspar that occurs in the geodes of the phonolite proves that for its separation a very active decomposition of the rock is necessary, which a volcanic rock so comparatively new as the phonolite has usually not yet undergone. Where such has occurred, as for instance in the transformation of trachytic rocks into alum-stone in the Hungarian volcanic zone in consequence of the exhalation of sulphurous acid, the small contents of baryta in the original rock has separated out in the form of heavyspar, which is found in several places in the cavities of the alum-stone.

The abundance or the lack of veins of heavyspar in stratified formations will therefore depend on how far the feldspar of the primordial rocks used up in their formation was already decomposed at the time of their deposition. In the Permian and many Triassic sandstones it is often still very fresh, in which case the presence of baryta in the rock can be easily detected, and the occurrence of veins of baryta at a considerable distance from the primordial rocks be easily understood. Where this is not the case the only possible supposition is that it was deposited by springs. The feldspars in the sandstones of the Rhenish slate plateau are very greatly decomposed, therefore veins of heavyspar occur very rarely in them; for instance near Michelbach and Oberrossbach in Nassau, Mittellach in the Bergischen, and in a few Siegener veins. When the rock is lixiviated under an increased pressure and temperature, as by the mineral springs at Ems, the traces of baryta in the water prove that some of this

base is always present. More frequently than in the stratified rocks of the Rhenish slate plateau do veins of heavyspar occur in the diabases that intersect them, as for instance in the Ferdinand Mine near Hirzenhain (5 cm.), Rehberg near Merkenbach (3–5 cm.), Theobald, Pallas and Orion near Burg (3–15 cm), and Rundbaum near Dillenburg. As the diabases, according to all examinations hitherto made, contain no orthoclase feldspar, the traces of baryta that the careful researches of Petersen and Senfter have always found in the rock can be contained only in their triclinic feldspars. This is all the more probable since Descloizeaux has very recently discovered a triclinic feldspar that must be regarded as nothing else than a baryta-labradorite.

According to this it would always be the baryta-contents of the feldspars that concentrate themselves in the veins of heavyspar; for the barytic micas have been first discovered by Oellacher in a few places in Tyrol and by me in Salzburg, and therefore cannot yet be taken into consideration here.

A second important veinstone, which usually accompanies the heavyspar in the Black Forest, is fluorspar. Up to the present time, however, I am aware of fluorspar only at one point in the region of the porphyritic granite, viz., in the Hesselbach valley, near Oberkirch, where there is a vein from 4–9 feet wide. The accompanying minerals, which occur in smaller quantity, are heavyspar and limonite; copper pyrites being observed in only one small grain. The country-rock is in a completely decomposed condition. In far smaller quantity has fluorspar occurred in the similar rock at the Hermann mine near Goerwihl, not far from Waldshut.

In the region of non-porphyritic granite the fluorspar is nowhere concentrated in any quantity in the northern Black Forest. Although it occurs in nearly all the metallic veins, the heavyspar always predominates, as in the Neuglueck Mine, King David and Daniel, near Wittichen. In the south it occurs only in association, for instance with copper pyrites at the defunct Hausen iron smelting-works in the Wiesenthal. Direct *points d'appui* for judging of the mode of formation of the fluorspar are not afforded by these veins. But even here it must be carefully noted that the oligoclase and mica of the country-rock of the veins are always equally and much decomposed ; and ferric oxyd occurs in quantity, viz., individually in the *Salbaender*, or as the colouring substance of the flesh-red baryta. Similar phe

nomena occur in the large pegmatite vein of the Gleisinger Rock in the Fichtelgebirg, in whose fissures violet-blue fluorspar and iron-mica occur together in exact proportion as the dark mica (rich in iron)* and the oligoclase are decomposed. Here, as I already advanced in 1865, there remains no doubt that the origin of the fluorspar depends upon the reaction of the potassic fluoride, that is derived from the mica, with the calcic carbonate from the oligoclase. The spathic iron, which occurs in scales in the fine crevices, is ferric oxyd that separated out of the mica at the same time; and upon the more complete decomposition of the rock it has even concentrated itself into a deposit of schistose very pure spathic iron, which has been worked for some time past. Baryta does not occur here; for the feldspar (completely changed into pinitoid) that furnished the lime is in its fresh condition an oligoclase free from baryta, which contains, according to Gerichten:

SiO_2	61.36
Al_2O_3	22.25
Fe_2O_3	1.60
CaO	1.10
MgO	Trace
Na_2O	11.06
K_2O	2.07

The orthoclase of the rock is very much reddened, but not yet changed into pinitoid.

In the Black Forest the veins richest in fluorspar are those in decomposed gneiss, e. g., Friedrich Christian in Schapbach, Teufelsgrund in the Muensterthal, Stephanie near Schoenau, Maus near Todtnau and Neuglueck near St. Blasien; numerous other mines also contain the mineral, although not in such quantity as in the Friedrich Christian, where 714 cwt. were mined in the years 1853–1857 alone. The production continued until 1876 in the so-called Fluorspar Shaft, where it was six feet wide. Fluorspar is one of the minerals that with especial clearness prove the co-operation of organic subtances in the formation of ore-deposits. The crystals are almost always coloured by organic dye-stuffs, sometimes dark violet (Schoenau), pale violet (Muensterthal, Schapbach), light sea-green (Schapbach, Todtnau), and

* The clear potash-mica that is also present undergoes decomposition only much later.

by drying to 100° C. suffer a loss corresponding to the quantity of the dye-stuff. Pale sea-green fluorspar from Friedrich Christian (Sp. gr. 3.169) showed a loss of 0.202 per cent., while pale violet from the same place with sp. gr. 3.184 lost only 0.2005 per cent.

While fluorspar is almost never wanting in the metallic veins that traverse the gneiss of the Black Forest, it is almost entirely unknown in those that similarly carry galena, copper, pyrites and blende in the Rhenish slate plateau. As the sandstones and clayslates of that region are doubtless nothing but the finely triturated *débris* of older rocks, viz., of gneiss and granite, we must assume that the mica of the latter was before its re-deposition very much decomposed and already deprived of its fluorine; as also the feldspar of its baryta (*vide supra*). It seems to me that in this way a chief difference in the mode of formation of metallic veins in primitive rocks and in sedimentary fragmental rocks would be naturally explained. The occurrence of both minerals in the English Mountain Limestone is quite different; but I do not know the conditions sufficiently to venture to express an opinion.

I come now to the most important part of my task, viz., *the proof of the presence of the heavy and precious metals in silicates.* It was known in this connection that the olivine rock and the serpentine formed from it always contained copper, nickel and cobalt: e. g., according to Stromeyer the olivine from the basalt of Giesen 0.37, that from Kosakow in Bohemia 0.33, and precious chrysolite from Egypt 0.32. I have found that this nickelous oxyd is always accompanied by cobalt, but in far smaller quantity. Herr Geh. Rath Woehler had the kindness to have both metals determined in the olivine from Nauroth near Wiesbaden, furnished by me in 1869. In 100 parts there were 0.307 nickelous oxyd and 0.006 cobaltous oxyd. Still more recently has it been shown that nickelous oxyd occurs very constantly also in the older eruptive lime-olivine rocks—the palaeopikrites: in the palaeopikrite of Dillenburg, 0.162—0.666 per cent., and is accompanied by copper, cobalt and bismuth. The palaeopikrite from Ullitz and other places of the Fichtelgebirg behaves similarly, and the far younger pikrites from Maehren and Austrian Silesia according to my repeated experiments contain the same elements; but no quantitative determinations have yet been made. In the Nassau palaeopikrites it can be proved that the percentage

of nickelous oxyd increases in the same ratio as the transformation of the lime-olivine into serpentine progresses. In the stone of the Black Rock near Tringenstein, which contains 20 per cent. lime-olivine to 40 per cent. serpentine, it amounts to 0.162 per cent: but in that of the Huelfe Gottes Mine near Nanzenbach. with only some seven per cent. lime-olivine and 50½ per cent. serpentine, it already reaches 0.666 per cent. In the fresh rocks, so far as known, no nickel deposits occur, but only in the highly decomposed. In the greatly serpentinised palaeopikrite of the Huelfe Gottes such a deposit has been mined for twenty years, whose ore according to Casselmann, is a mixture of bitterspar, ferrous carbonate, copper pyrites (21.98 per cent.=7.60 per cent. copper), millerite (6.68 per cent.=2.64 per cent. nickel), sulphuret of bismuth (2.05 per cent.), iron pyrites (7.72 per cent.) with 0.30 per cent. quartz and red hematite; but the relative quantities of the sulphurets vary so much that ores occur also with almost equal percentages of nickel (6.13) and copper (5.39). Both here and in the entirely similar ore-deposits of Bellnhausen near Gladenbach (as I have already shown) there is no doubt thåt the slight percentage of nickel in the palaeopikrite has been concentrated and precipitated by contact with sulphuretted fluids, and in this way has yielded workable quantities of ores of nickel. In the geodes nickel pyrites is always the sulphuret last deposited: a phenomena that recurs in many other metallic veins (Joachimsthal, Andreasberg, Huckelheim and Bieber in the Spessart, etc.) and is connected with the comparatively ready solubility of the sulphuret in sulphide of ammonia and similar soluble sulphur-compounds of alkalies and alkaline earths. It is overlaid only by calcspar, which mineral, moreover, occurs also in small stringers that intersect the ore-deposit and contain arsenical nickel and smaltine. It is a familiar fact that cobalt concentrates itself as an arsenical compound out of ores very poor in this element, everywhere where arsenic is present in any quantity, as, for instance, in the magnetic pyrites of Wiersberg in Oberfranken, as I have already shown, where it forms cobaltous mispickel.

Olivine or chrysolite is a very basic compound (R: Si=2: 1); but neutral silicates also contain heavy metals, and most prominently hornblende and augite.

Next in regard to *hornblende*, of which I have tested several varieties for heavy metals. By testing samples of 20—40 grammes each—I found along with very much iron:

1. In basaltic (crystalline) hornblende from porphyritic basalt from Liebhards (Rhone)	*Cu not determinable. Co very evident.*
2. In the hornblendic schists from Goldbach near Aschaffenburg	*Copper and cobalt.*
3. Ditto from Oberkotzan near Hof	*Cu faint, Co evident.*
4. Ditto from Albbruck near Waldshut (Baden)	*No Cu, no Co, only Mn.*
5. Ditto from Webicht, near Schmalkalden	*No Cu, Co very evident.*
6. Ditto from Johanngeorgenstadt in the Erzgebirg	*Cu comparatively much, Co less, but very evident.*
7. Dark-black hornblende with olive-green streak from Prackendorf in Hungary	*Cu and Co very evident.*

Up to this time cobalt had been observed in no hornblende, and copper only in the actinolite of Reichenstein (0.40 per cent., Richter) and in the Smaragdite of Corsica (1.5 per cent., Vauquelin). Whereas copper and cobalt in consequence of the intense borax beads that they give before the blowpipe can be easily and surely discovered, even in a very small quantity of the hornblendes that have been so far examined; nickel could but very seldom be discovered accompanying the cobalt, as it usually occurs in still smaller quantity.* Whilst in the olivine of Neurod, the ratio of Ni : Co. was about as 51 : 1, it might probably be reversed in many hornblendes. But considerably larger quantities than hitherto must be operated upon, in order to separate the nickel, when it occurs, from the cobalt, and determine it with certainty. I have not yet examined the hornblendes for bismuth and arsenic. That the latter occurs in hornblendic schists I doubt so much the less from having found it to my very great surprise so long ago as 1862, in its native form, in the quartz stringers of the rock near Maisach, not far from Oppenau. Whenever a violent decomposition of the hornblendic schists occurs, which, however, has but seldom been observed, smaltine

* Certain Scandinavian hornblendic rocks behave evidently quite otherwise in this respect, since they contain highly nickeliferous magnetic pyrites and iron-nickel pyrites.

can separate out from them; and this is certainly the reason why certain cobalt veins at Annaberg always grow considerably richer where they intersect hornblendic schists. Up to the present time I have come to no definite conclusion as to whether the pyrites that occur in quantity in the hornblendic schists (*e. g.* near the Gutach-Muendung, not far from Hausach in the Black Forest), and sometimes in particles as large as peas, separated out immediately on the formation of the rock, or were first formed subsequently, but I am inclined to believe the former, because the pyrites appear firmly grown together with perfectly fresh mica and hornblende. In these pyrites, which consist principally of magnetic pyrites accompanied by only a little iron and oopper pyrites, Petersen, who examined them at my request, determined on the average: S 39.93, As 0.15, Pb 0.10, Cu 0.36, Fe 58.31, Ni and Co 0.63, Ti and Mn trace, Bi and Ag slight traces.

The pyrites contain the heavy metals also in much the same ratio in which I have found them in hornblendes free from pyrites.

Several varieties of augite were examined, but naturally only such as form elements of rocks. The following results were obtained:

1. Augite out of a stream of the Somma, near Cisterna.*	*Cu and Co evident.*
2. Augite in the porphyritic basalt from Liebhards intercrystallised with hornblende No. 1: powder dark greenish-gray.	*Cu comparatively much; apparently enough to determine quantatively; Co plain (along with much Mn).*
3. Augite of the porphyritic basalt from Eckardtsberg, near Breisach: * powder light-gray.	*Cu no reaction.* *Co evident.*
4. Augite of the angite.porphyry of the Fassathal: powder clear greenish-gray.*	*Cu no reaction.* *Co evident.*

* There were only a few pure crystals to be had.

5. Augite of the granular diabase from Waeschgrund, near Andreasberg (Harz): powder light greenish-gray.	*Cu and Sb little; As still less. Pb much; Co evident. Ni very evident.*
6. Similar augite from Koenigsberg, near Giessen: powder light greenish-gray.	*Cu comparatively much; apparently enough to determine quantitatively. Co evident.*
7. Similar augite from Kroetenmuehle, near Hof (Fichtelgebirg): powder light greenish-gray.	*Cu and Co evident.*

As in the hornblendes, cobalt has been found in very small quantity in all the augites tested, while copper could not be found in every one of them, although in the augite from the diabase of Koenigsberg, near Giessen, and from the porphyritic basalt of Liebhards enough was present to determine quantitatively. Both elements occur in the augites of very ancient and also of very modern eruptive rocks. In the diabases and therewith associated *Schalsteine* of Nassau copper pyrites occurs in direct ratio as the decomposition of the rock has progressed, as is proved by the numerous veins (some thirty) in the neighbourhood of Dillenburg, and some ten in the valleys of the Lahn and Weil near Weilburg, which all contain ore only within this rock and are richest where they intersect beds of red hematite. But on passing into the Cypridina slates, sandstones, etc., the veins become barren. Galena and blende occur but rarely in the Nassau diabases associated with eopper pyrites in calcspar fissures or in veins of copper pyrites, as, for instance, in the Fortunatus Mine, Guade Gottes and Gold Mine. Self-evidently the former occurs in the diabase region only in small veinlets (deserted mine Goldgraben near Weinbach, Merkenbach near Herborn) or associated with arsenical tetrahedrite * (Mehlbach

* Tetrahedrite with a maximum of one per cent. siver and galena occurred frequently in separated *Mitteln* at Weyer, the former where *Schalstein*, and the latter where diabase formed the immediate counry rock.

Mine near Weilmuenster, and Weyer near Runkel). Where the diabase became compact and fresh in the depth the veins were compressed into a simple crack filled with clay and barren of ore. Lead, zinc and arsenic were found by Senfter in Nassau diabases; therefore it cannot be wondered at if, under favourable circumstances, they concentrate themselves into ores. But still more striking is the connection between ore-bearing and the constitution of the neighbouring plutonic rocks at St. Andreasberg in the Harz. Here the clay-slates through which the veins of ore run are bounded on the north by granite and to the south by diabase. The augite of the latter contains, as mentioned above, more lead than copper, more antimony than arsenic, more nickel than cobalt; all of which corresponds to the distribution of these elements in the veins of ore. I have not yet tested this augite for silver and zinc; but I shall repeat my tests as soon as sufficient material reaches me. The latter metal was determined by Marx in 1868 to range from 0.0007–0.0014 per cent. in Central American hornblende-and augite-andesites. The occurrence of zeolites (analcime, chabasite, stilbite, apophyllite), otherwise unusual in metallic veins, but not rare in clefts of diabases, forms an additional and not unimportant argument in favour of the derivation from decomposed diabase of the solutions that are precipitated in metallic veins. The above-cited facts have fully established of what vital importance the contents of the augite in heavy metals are for the explanation of the mode of filling of the metallic veins in diabases and similar rocks.

Not only do the augites of the elder volcanic rocks contain heavy metals, but they have been found by me also in the younger and youngest such rocks; so also for instance the occurrence of cobalt and nickel in the nephelinite of the Katzenbuckel by Rosenbusch, of copper and bismuth in the basalt of the Schiffenberg near Giessen by Winter and Will, of lead in the basalt of Annerod by Engelbach and of arsenic and antimony in that of the Kaiserstuhl by Daubrée.

With time mettallic veins might form themselves also out of such rocks. At the present time in volcanoes also are the contents of augites in heavy metals sometimes very apparent. For the occurrence of copper-and lead-compounds in the lavas and fumaroles of Vesuvius and other volcanoes must always be ascribed to the augite's contents of these metals, which have

been changed into compounds with chlorine by long continued exposure to hydrochloric fumes.

The results from the examination of various micas are not less important than those yielded by olivine, hornblende and augite. But these are restricted to dark brown or black micas, which are usually curtly called "magnesia-micas" or "biotites"; but do not include the bright pure potash-micas or "muscovites," as these usually occur in the primordial rocks only as rarities and contain but 3-9 per cent. of iron, in whose company the heavy metals are usually found. After I had once found (in 1870) copper and cobalt in a dark brown mica out of the gneiss from Petersthal in the Renchthal I pursued the subject farther and was encouraged in my researches by Hardman's discovery in Dublin of zinc, copper and lead in micas from the Irish granites In order to obtain a commensurate result from my work I had naurally to separate out and examine as large quantities as possible of fresh micas from the primary rocks of various ranges. Only from a few localities could I obtain some 30 grammes, but from others far less. The entire results are set forth in the following table:—

	Ag	*Pb*	*Zn*	*Cu*	*Co*	*Ni*	*Bi*	*As*
There is contained in mica from gneiss, Petersthal	—	—	—	v. evident	evident	—	evident	—
" " " " " Wildschapbach	—	evident	—	"	"	—	"	—
" " " " garnet gneiss, Wittichen	—	—	—	—	"	evident	"	—
" " " " gneiss, Zindelstein	—	—	—	v. evident	"	—	"	—
" " " " " Rippenweiher (Odenw*)	—	—	—	—	"	—	—	—
" " " " " Damm near Aschaffenburg	—	—	—	v. evident	v. evident	—	evident	—
" " " " decomposed gneiss, Hoerstein	—	—	—	"	"	—	"	evident**
" " " " gneiss, Wenneberg (Rics) *	—	—	—	—	evident	—	—	—
" " " " garnet gneiss, Bodenmais	—	—	—	evident	v. evident	—	—	—
" " " " porphyritic granite, Altenstein, (Thuringian Forest)	—	—	—	"	evident.	—	evident	—
" " " " porphyritic granite, Haeg, (Black Forest)**	—	—	—	—	v. evident	—	—	—
" " " " granite, Schapbach	—	—	—	v. evident	evident	—	—	evident**
" " " " " Tryberg	—	—	evident	evident	"	—	—	—
" " " " " Sulzbaechle near Schiltach (Muendung)	distinct clouding by HCl	—	—	evident	v. evident	—	—	evident**
" " " " vein-granite (pegmatite) Heidelberg.	—	v. evident	—	—	evident	—	—	—

* Only a small quantity was at my disposal.
** Determined with an improved Marsh's apparatus.

Cobalt, the most easily detected metal, is absent from none of the micas examined by me; most of them contain copper also, often indeed in comparatively large quantity, *e. g.*, that from Petersthal, Zindelstein near Hammereisenbrech and Schapbach in the Black Forest, Damm and Hoerstein in the Spessart, and it is then usually accompanied by bismuth. Nickel is rarer, but it also has been found, for instance, in the mica of the garnet-gneiss from Wittichen and that of the kersantite of Nassau. Arsenic was detected only in that from Schapbach, Schiltach and Hoerstein. The micas from the granitic region of Wittichen and Schapbach contain traces of silver, but no lead. This, however, has been very clearly detected in the mica of the gneiss of Schapbach.

There are in the gneiss, as well as in the region of hornblende-slates, ore-deposits whose sulphurets are so intermingled with silicates, micas, cordierite and feldspars that they can hardly be considered otherwise than as having been separated out at the time of formation of the gneiss. To this class, in my opinion, belong, for instance, those of Bodenmais in Bavaria, Todtmoos in Baden and Orijaerfi in Finnland, which principally contain magnetic pyrites, blende, copper pyrites and galena, and those of Modum in Norway and Tunaberg in Sweden, containing cobaltine and copper pyrites. In these ore-deposits occur again all the heavy metals that were found in the micas of the gneisses. In the case of a great excess of iron and lack of arsenic, only magnetic pyrites occurs, which, however, usually carries with it the remaining metals of the iron group. When, at the same time, as at Bodenmais, it contains but little nickel and cobalt, they can still be detected, and can be quantitatively determined in the pyrites of Kleofa (3.044 Ni, 0.094 Co, *Berzelius*), Todtmoos (Ni 1.82, Co 0.48, *Hilger*) and Horbach near St. Blasien (Ni 3.86, *Rammelsberg*, 11.2, *Knop*); and in this latter case are technically useful. Whenever arsenic occurs in these ore-combinations, the cobalt concentrates itself in the form of cobaltine, while the iron and copper form sulphurets free from arsenic.

The metallic veins in the gneiss region vary greatly in regard to their filling, which I seek to explain only by the chemical composition of the dark mica contained in the gneiss in question. In the gneiss of the Spessart, whose dark mica contains cobalt and arsenic along with copper and bismuth, occur the well-known

smaltine veins of Bieber, in many places also (Alzenan, Sommerkal, etc.) stringers of copper ore have been found, which contain principally copper pyrites, but also locally bornite and cobaltous tetrahedrite. The latter mineral, which was first closely examined by me in 1862, occurs evidently in the stringers of those gneisses whose micas contain all the above-mentioned elements—but copper, iron and sulphur in excess over cobalt and arsenic. Galena, as far as I know, has never been found in the Spessart. All the more frequently is it found, either with or without copper pyrites, in the vein-region of the neighbourhood of Schapbach, the mica of whose gneiss contains copper, lead and bismuth. Antimony and arsenic were not discoverable in the mica, and occur only in minimal traces in the veins bearing galena : the former in the very rare antimoniate of lead, the latter in mimetisite, green lead ore (0.61 arsenic acid, Petersen), and in roselite, which was observed only once in very slight quantity. The latter mineral and the equally rare heterogenite seem at the first glance alone in the metallic vein to represent the cobalt repeatedly observed in the mica ; but the galena also contains cobalt, nickel and bismuth, which have been precipitated here along with the ore that is present in the greatest quantity, in precisely the same way as elsewhere with magnetic pyrites. A great number of veins of the Black Forest are filled in the same way ; but others, viz., those of the region of Geroldseck and of the Muensterthal contain, along with galena, much blende and no copper pyrites ; therefore we may infer that they obtained their metals from mica rich in zinc and free from copper. In respect to the veins of Wolfach, Welschensteinach, etc., which are rich in antimony and silver, I must not express any opinions until I have examined the micas of the country-rock : possibly they will give results similar to those from the augite of Andreasberg.

The marked contrast between the ore-districts of the gneiss of Schapbach and the granite of Wittichen, which are scarcely five miles apart, is explained by the composition of their micas. That of Wittichen is free from lead, but contains silver, arsenic, bismuth, cobalt, nickel and a little copper, viz., all the elements that occur in the metallic veins there ; towards the west they are united to a cobaltous tetrahedrite, but in the east are separated into native silver, cobalt-nickel ores and copper-bismuth compounds.

As we may observe, these investigations, which could not be

continued to the micas of other rocks for want of time, have yielded as striking and important results as those into the olivines, augites and hornblendes; and the theory of the derivation of the ores from the country-rock has been proved for a number of localities. I have not yet been able to obtain mica from the neo-volcanic rocks in sufficient quantity to detect the heavy metals in them, in the same way as in augite and hornblende.

G. Bischof, who is well qualified to express an opinion on the mode of formation of metallic veins and also on chemical geology in general, stated, in the year 1866, in regard to the relations of silicates to the metallic veins: "However likely it may be that the metals of the sulphuretted ores are present as silicates in the country-rock, it is not yet certain." This can no longer be said, at least in the cases described above.

REVIEW.

THE ANTELOPE AND DEER OF AMERICA; by John Dean Caton, LL. D.; 8vo., 426 pp.; numerous cuts. New York (Hurd & Houghton). This valuable work has evidently been prepared with care by one who has devoted a great deal of time and study to our Antelopes and Deer. Mr. Caton has kept the American Antelope and several species of Deer in domestication for many years, and had the best of opportunities for observing their habits. His work contains many illustrations, and will, we are sure, be welcomed by both naturalists and sportsmen.

THE ROCKY MOUNTAIN LOCUST.*

By. C. V. Riley, Ph. D.

The subject which you have assigned to me is entitled The Rocky Mountain Locust and the Army Worm. Both these insects are extremely injurious to the agriculture of the United States, and as it would be difficult to do justice to both in the compass of a brief address, I shall confine my remarks at the present time to the first named. So much has been written and said, by myself and others, upon this Rocky Mountain locust during the past two or three years that it would seem difficult indeed to say anything about it that is new or of value. Yet I may safely assert that most of the definite and accurate knowledge regarding its habits and life history was first given to the world during the present year.

Though popularly known as the "grasshopper," yet the term "Rocky Mountain locust," proposed by myself, has been very generally adopted as most appropriate. The insect belongs to the same family as the locusts of Scripture. The term grasshopper is very loosely applied to many insects that hop about in grass, but strictly belongs to the long-legged, long-feelered species. Locusts have short and stout legs, short and stout feelers, and are mute, or, if they stridulate at all, do so by rubbing the hind thighs against the sides of the folded front wings; their prevailing colour is brown; they are gregarious, and they oviposit in the ground by means of short, drilling valves. True grasshoppers have long and slender legs and feelers, and stridulate by vibrating the front wings, which in the males are furnished, generally near the base, with talc-like plates crossed by enlarged and hollow veins; their prevailing colour is green; they are solitary, and they mostly oviposit in different parts of plants, by means either of a sword- or scimeter-shaped ovipositor. It is the grasshoppers, the katydids (which are a tree inhabiting section of them), and the crickets which make field and wood resound with shrill orchestry in autumn; but the locusts take no part in the concert. While our insect belongs,

* Reprinted from the "American Naturalist."

therefore, to the same family as the locusts of Scripture, those people are greatly at sea who imagine it be specifically identical with any of the Asiatic or European species. It is known to entomologists as *Caloptenus spretus*, and is purely American, since it does not inhabit any other continent.

Evolutionists believe—and I am one of them—that existing species are but the modified descendants of pre-existing species. The present species of a genus have at sometime, more or less remote, had a common ancestry. All life exhibits a certain power of adaptation to surrounding conditions, and through what is known as "natural selection" (two words which by Darwin's pregnant pen have come to express volumes of facts and consequences), coupled with other less easily formularized laws, the fauna and flora of the globe have been as profoundly changed as have its physical conditions. The influences that have thus worked in the past are still working at present—less rapidly, perhaps, in the main, but none the less effectually. Among higher and more complex animals the changes are slow and not very noticeable; the species have become, in most cases, markedly differentiated, and their characters are well fixed. Among lower organisms these changes are more obvious, and naturalists are sorely puzzled in their endeavours to grasp and express them. This is especially the case among insects. We have the simple variation from the typical characters of a species; we have phytophagic varieties, or those departures from the type that result from the kind of food assimilated during growth; we have phytophagic species, or those variations which have become fixed and permanent in the adolescent or immature stages through some peculiar and fixed habit, without having yet modified the imago or mature state; we have geographical variation, increasing—usually with distance—until the separation from the type is sufficient to be indicated by what we call race; we have seasonal variation, sexual variation, and, finally, we have the terms dimorphism, heteromorphism, and many other *isms*, to express still other variations. In short, in the strain, the breed, the sport, the tribe (in the popular sense), the variety, and the race, we have so many terms invented to indicate some of the more patent steps in the evolution of one species from another, and between them all there are so many shades of variation for which no words have yet been coined, that the naturalist who takes a comprehensive view of life upon our planet finds that what we have chosen

to call *species* are often with difficulty separated from each other; that they have, in fact, no real existence in nature. All our classificatory divisions are more or less conventional. They are excellent as aids to thought and study, but misleading when believed—as they popularly are—to express absolute creations that have existed for all time.

As with other species, so it is with the locust under consideration. The species is a denizen of the plains regions of the Rocky Mountains to the west and northwest of us. It breeds continuously and comes to perfection only in those high and dry plains and prairies; and though at intervals it overruns much of the lower, moister country to the east and southeast, yet it never extends in a general way to the Mississippi. But there are species east of the Mississippi that are so closely allied to it that the ordinary farmer cannot, without a little special knowledge, appreciate the difference, and entomologists, even, are not of a mind as to whether they should be called species, varieties, or races, etc. The two species most closely allied to the Rocky Mountain locust are the red-legged locust (*Caloptenus femur-rubrum*) and the Atlantic locust (*Caloptenus Atlantis*). Both are wide-spread species, but are either rare or do not occur in the home of *spretus*. The differences between the three species I have elsewhere given in detail; for the present purpose it suffices to say that the distinguishing characters, most easily observed by the non-entomologist, are the relative length of the wing and the structure of the terminal joint of the male abdomen. The Rocky Mountain species has the wings extending, when closed, about one-third their length beyond the tip of the abdomen, and the last or upturned joint of the abdomen narrowing like the prow of a canoe, and notched or produced into two tubercles at top. The wings of the red-legged locust extend, on an average, about one-sixth their length beyond the tip of the abdomen, and the last abdominal joint is shorter, broader, more squarely cut off at top, without terminal tubercles, and looks more like the stern of a barge.

The Atlantic locust, though smaller than either, is in other respects intermediate between the two, but in relative length of wing and structure of the anal joint in the male, most related to *spretus*.

We should encourage the locust's natural enemies. Practically this is not possible with many of the smaller parasitic and preda-

ceous kinds; they are beyond our control. With many of the larger locust enemies, however, as in the case of birds, it is feasible. One of the most effectual ways of accomplishing it is to offer a reward for hawk-heads, as Colorado has done. The introduction of such hardy locust-feeding birds as the grackle and the English rook may be attended with benefit, and the Commission of which I am a member, will try the experiment. The destruction of the eggs is of the utmost importance.

The experience of the present year has proved, what I have always insisted on, that in the more thickly-settled portions of the country, by proper organization and intelligent effort, man may master the young insects. Men of large experience admit that a crop of young insects is not more difficult to cope with than a crop of weeds. It is different with the winged insect, and the question is: "Can anything be done to protect our farmers from the disastrous flying swarms?" At first view it would seem hopeless. Yet there is already a partial answer to the question. There is a popular notion that this pest breeds in and comes from sandy, desert countries. It is a popular error. The insect cannot live on sand, nor does it willingly oviposit in a loose, sandy soil. It does not thrive on cacti and sage bush. It flourishes most on land clothed with grass, in which, when young, it can huddle and shelter. It can multiply prodigiously on those plains only that offer a tolerably rich vegetation,—not rank and humid as in Illinois, but short and dry,—such as is found over much of the plains region of the Northwest, already referred to. Now the destruction of the eggs, which is so practicable and effectual in settled and cultivated sections, is out of the question in those vast unsettled prairies; but the destruction of the young locusts is possible. Those immense prairies are not only susceptible of easy burning, but it is difficult to prevent the fire from sweeping over them. Now some system of preventing the extensive prairie fires that are common in that country in fall, and then subsequently firing the prairie in the spring, after the bulk of the young hatch, and before the new grass gets too rank, would be of untold value if it could be adopted. At first blush such a proposition seems utopian, but the more I study the question, and the more I learn of these breeding grounds, the more feasible the plan grows to my mind. The Dominion Government has, fortunately, a well-organized mounted police force which constantly patrols through the very regions where the insects breed,

north of our line. This force is intended to see that the peace is kept, to watch the Indians, to enforce the laws, and perform other police duties. It could be utilized, without imparing its efficiency as a police force, in the work I have indicated; or it might be augmented for that same work. I have conversed with the Canadian ministers of agriculture and of the interior, and with Governor Morris, on the subject, and they see nothing impracticable in the plan. We have on this side the line a number of signal stations and military posts in the country where the insect breeds. Now, I would have our own military force co-operate with the Dominion police force as a locust vigilance committee. Under the intelligent guidance and direction of some special commissioner or commission, I would have that whole country systematically studied every year by such a force, with reference to the abundance or scarcity of the locusts. I would have such a vigilance force, by a proper system of fire-guards and surveillance, prevent the fall fires in sections where the insects or their eggs were known to abound, in order to burn them at the proper time the following spring; and where such precaution was not possible or had failed, and the winged insects at any season were numerous, I would have their movements carefully watched, and communicated daily to the signal officers, to be by them communicated to the farmers. In this way the latter could be fully forewarned of approaching danger. I would have the Western farmers adopt some general plan of defence against possible invasion. The straw that is now allowed to rot in sightless masses as it comes from the thrasher, and that encumbers the ground unless burned, should be utilized. Let it be stacked in small pyramids at every field corner, and there let it remain until the locusts are descending upon the country. Then let the farmers in a township or a county, or in larger areas, simultaneously fire these pyramids, using whatever else is at hand to slacken combustion and increase the smoke, and the combined fumigation would partially or entirely drive the insects away, according as the swarm was extended or not. In short, not to weary you, I believe, first, that by proper co-operation on the part of the two governments interested, the excessive multiplication of this destructive insect may be measurably prevented in its natural breeding-grounds, and that the few thousand dollars that would be necessary to put into operation intelligent co-operative plans were most trifling in view of the vast interests at stake. In fact, with an efficient and prop-

erly organized department of agriculture, liberally supported by Congress, and aided by the war department and the signal bureau, the plan could soon be perfected and carried out at minimum expense. I believe, secondly, that where the insect's multiplication cannot be prevented in its natural breeding-grounds our farmers in the more thickly-settled sections may, by the use of smoke, measurably turn the course of invading swarms and protect their crops,—obliging the insects to resort to the uncultivated areas.

Were the injury to continue for another three or four years as it has for the past four, and were the Western farmers to suffer a few more annual losses of forty million dollars, such schemes as I have suggested would soon be carried out. The danger is that during periods of immunity, indifference and forgetfulness intervene until another sweeping disaster takes us by surprise.

Rules greatly assist in the solution of any problem, and in proportion as we get at a knowledge of the laws governing this Rocky Mountain locust shall we be able to overcome it. The country which it devastates is so vast, and the question as to its origin and the causes of its disastrous migrations is so complicated, that a limited study is apt to beget doubt as to whether there are any laws governing the insect or any rules for our guidance. The facts of sociology are so innumerable that the ordinary gleaner of them reaps but confusion. It requires the genius and comprehensiveness of a Herbert Spencer to deduce principles therefrom,—to perceive the laws by which society is moulded. The vain, delusive confidence begot of first study of any difficult subject—that follows superficial knowledge,—reacts in doubt and diffidence upon deeper delving and more thorough study.

"The more I learn the less I know" is a paradoxical but very common remark. It is only after passing through this period of doubt in any inquiry that we can begin to see the light; and in this locust inquiry it is only after accumulating facts and experiences until they almost overwhelm us with their complexity that we can begin to generalize and deduce rules.

The history of this insect east of the Rocky Mountains, when viewed from a comprehensive stand-point, presents certain well-marked features. We have first the migration of winged swarms in autumn from the higher plains of the West and Northwest, into the more fertile country south of the 44th parallel and east

of the 100th meridian. It is the more fertile and thickly-settled country south and east of the limits indicated which suffer most, both from the insects which sweep over it and from the young that hatch in its rich soil; and it is principally this country which I have designated as being outside the insects' native home, and in which it can never become a permanent resident. The species does not dwell permanently even in much of the country north and west of those lines, but it flourishes more and more toward the northwest. In short, the vast hot and dry plains and prairies of Wyoming, Dakota, and Montana, and the immense regions of a similar character in British America, comprising what is known as the third prairie plateau or steppe, are congenial breeding-grounds. and supply the more disastrous swarms which devastate the lower Missouri and the Mississippi valleys. That Northwest country may be depicted as a vast undulating prairie sea, now stretching in sandy barren tracts which bring forth little else than the cactus or sage-bush; now rolling for hundreds of miles, and covered with the buffalo grass (*Bucloe dactyloides*) and other short nutritious grasses, and again producing a ranker prairie growth wherever there is increase of moisture. Another peculiarity of that country is that though the spring opens as early, even away up in the valley of the South Saskatchewan, as it does in Chicago, yet the vegetation often becomes parched up and burned out by the early part of July. Now, *Caloptenus spretus*, though coming to perfection in high and dry regions, is nevertheless fond of succulent vegetation, and instinctively seeks fresh pastures whenever those of its own home are dried up. It may sometimes happen, indeed, that the species will die in immense numbers if the scant vegetation where it breeds should dry up before the acquisition of wings, just as another species (*Œdipoda atrox*) has perished in immense numbers the present season in California by the excessive drought that has prevailed there; but ordinarily the insects will be full grown and fledged before the parched season arrives, and the ample wings of the species prove its salvation. Again, it may become so prodigiously multiplied during certain seasons that everything green is devoured by the time its wings are acquired.

"In either case, prompted by that most exigent law of hunger, —spurred on for very life,—it rises in immense clouds in the air to seek for fresh pastures where it may stay its ravenous appetite. Borne along by the prevailing winds that sweep over these

immense treeless plains from the northwest, often at the rate of fifty or sixty miles an hour, the darkening locust clouds are soon carried into the moist and fertile country to the southeast, where with sharpened appetites they fall upon the crops, a plague and a blight. Many of the more feeble or of the more recently fledged perish, no doubt, on the way; but the main army succeeds, with favourable wind, in bridging over the parched country which affords no nourishment. The hotter and dryer the season, and the greater the extent of the drought, the earlier will they be prompted to migrate, and the farther will they push on to the east and south."*

We have, second, the return migration toward the northwest from the country south and east of the lines already indicated, of the progeny of invading swarms, as soon as wings are acquired the next summer. Time will not permit me to present the explanation of this return migration. In the work just quoted I have discussed its causes, the reasons why the species cannot permanently thrive in the Mississippi valley, and the conditions which prevent its establishment there.

We have, third, the eastern limit of the insects' spread along a line broadly indicated by the 94th meridian, and the consequent security from serious injury east of that line.

These three features of our disastrous swarms—the return migration from the southeast country (which implies only temporary injury therein), and the eastern limit,—may be stated as laws governing the insect east of the Rocky Mountains. They have constantly been urged by me, and the present year's experience has confirmed and verified them. I think I may safely present a fourth, namely, that the eggs are never laid thickly two successive years in the same regions.

In mapping out the country in Kansas and Missouri in which eggs had been laid most thickly in 1876, I was struck with the fact that the very counties in which the young insects had been most numerous and disastrous in 1875 were passed by or avoided, and had no eggs of any consequence laid in them in 1876. The fact was all the more obvious because the insects did much damage to fall wheat, and laid eggs all around those counties, to the north and south and west. From the exhaustive report on the

* Locust or Grasshopper Plague, page 57. Rand, McNally & Co., Chicago.

insect in Minnesota, made by Mr. Allen Whitman, it was also very obvious that those portions of that State which had been most thickly supplied with eggs in 1875, and most injured by the young insects in 1876, were the freest from eggs laid by the late swarms of the latter year, notwithstanding counties all around them were thickly supplied. I was at first inclined to look upon these facts as singular coincidences only; but instances have multiplied. A remarkable one has been furnished me by Gov. A. Morris, of the northwest territory. You are well aware that in 1875 the locusts hatched out in immense numbers and utterly destroyed the crops in the province of Manitoba. Now, in 1876 they were very numerous over all the third prairie steppe of British America, and largely went to make up the autumn swarms that came into our own country a year ago. Governor Morris started late in July of 1876 from Winnipeg northwest to make a treaty with certain Indians, and during the first five or six days of August he encountered innummerable locust swarms all the way from the forks of the two main trails to Fort Ellice. The wind was blowing strong from the west all the time,—just the very direction to carry the insects straight over into Manitoba. The Governor watched their movements with the greatest anxiety, fearing that the province would again be devastated as it had been the previous year. Yet during all the time he was passing through the immense swarms, they bore doggedly to the south and southeast, either tacking against the wind or keeping to the ground when unable to do so. Nothing was more remarkable than the manner in which they persisted in refusing to be carried into Manitoba. A few were blown over, but did not alight, and the province seemed miraculously delivered. Mr. Whitman tells me, again, that in settling the present year the insects avoided those counties in Minnesota in which they had hatched most numerously and done greatest injury, but selected such as had not suffered for some years past.

It is evident that there is more than mere coincidence in these occurrences, and I may say that upon looking more deeply into the matter I cannot find a single instance where eggs have been laid thickly for two successive years in any invaded country. This is a most important fact. During a season of great devastation there is a natural tendency among the more pious portion of the community to beseech the Almighty, by prayer, fasting, and humiliation, for deliverance. How greatly their faith must

be strengthened by facts such as I have just stated! As a naturalist it is my province to study the reasons for the facts. Whether what I call the working of natural laws be called by others the instrumentality of Providence is quite immaterial.

To recapitulate, I think we may safely deduce the following four rules as governing the Rocky Mountain locust east of the mountains from which it takes its name:—

(1.) The northwest origin of the more disastrous fall swarms that overrun the more fertile country south of the 44th parallel and east of the 100th meridian.

(2.) The return migration toward the northwest of the insects that hatch in the country named.

(3.) The eastern limit of the insects' spread along the 94th meridian.

(4.) No two successive hatchings of an extensive and disastrous nature can take place in the same region.

The possibility of exception to the rules would be in keeping with the character of all rules; but I am convinced that the exceptions will ever prove most trifling. Now there is a deal of satisfaction to be drawn by our farmers from these rules, which not only limit locust disaster but enable them to anticipate events; and I need hardly state that the accuracy of my own prognostications, repeatedly made during the past three or four years, was in no small degree due to them.

We have had the spectacle of the Rocky Mountain locust, in what I call the return migration, flying over some parts of the vast territory from the 29th parallel to the Dominion boundary line, and from the 94th meridian to the mountains, all along from the end of April till the beginning of August, and with so little injury that, with the exception of the case in Montana, just mentioned,* the question everywhere asked is, Where have the flying 'hoppers gone? What has become of them? I answer that, as in previous years, and as I have always held would be the case, they were, in the main, so diseased and parasitized that they dropped in scattered numbers and mostly perished on their northward and northwestward journey. This is no theory, but known to have been the case in the more thickly-settled parts of Kansas, Nebraska, Iowa, and Minnesota, from which the insects that had dropped have been reported, and in some cases sent to me. But

* Referred to in the portions omitted.—Ed.

as the flight is for the most part over the vast and thinly-settled plains of Indian Territory, Kansas, Nebraska, and Colorado, the number that has dropped and been lost to sight in said plains is infinitely greater than that which has been observed to come down in the more thickly-settled regions to the east.

The more dense and extensive swarms that flew before the 1st of July reached, I have little doubt, the great thinly-settled plains and prairie region of Northwest Minnesota, Dakota, Montana, and British America,—embracing in the latter case most of the country between the projected line of the Canada Pacific and the boundary line, and between Manitoba and the Rocky Mountains. I found the insects sparsely spread over the rank prairies west of Brainerd along the Northern Pacific and along Red River; and by this I mean that a few would hop from the grass at every step, wherever I searched for them. I met with only here and there a straggler in Manitoba; but early in July they flew from the south over the country west of the province, and reached the North Saskatchewan at several points, passing many miles north of Fort Carleton.

The insects that rose after the first week in July (mostly from restricted parts of Minnesota and Dakota) bore for the most part southwardly, while many of those which passed to the northwest earlier in the season returned. Thus, swarms more or less scattering have been passing for the past two months over parts of Iowa, Nebraska, and Kansas, in varying directions, but mainly to the south and southeast. They have lately reached into the Indian Territory. In no instance have they done serious damage, and the reports that come to me are singularly unanimous on this point. The movements of the insects that bred in Minnesota this year were very similar to the movements of those that bred there in 1876. They at first flew to the northwest, but were subsequently brought back, and travelled over parts of Iowa, Nebraska, and Kansas. The difference between the two years is that the flights that thus turned back on the original course in 1876 were recruited and followed by immense and fresh swarms from the northwest plains regions, where, far beyond the boundary line, they hatched and bred innumerably; whereas the Minnesota swarms of 1877 have not been recruited because there were few eggs laid in 1876, and no insects of any consequence reared in 1877 in said northwest country. It is upon this fact that I have founded the belief in no serious devastation in the southeast country this fall.

To those who pay little attention to the subject the disappearance of the swarms that left the Mississippi Valley is matter for wonder. "What is hit is history, but what is missed is mystery." Who, at the explanation of some simple trick or piece of legerdemain, has not smiled to think how easily he was baffled! But there are those who prefer the mystery of ignorance, and would much rather believe that the locusts have vanished in the heavens or been swept into the ocean than accept any explanation; and there are others who, from sectional feelings, would much rather believe that the insects have flown to Canada and New England than accept the facts.

MISCELLANEOUS.

Archæan of Canada. (Letter from Mr. Henry G. Vennor, of the Geological Survey of Canada, to J. D. Dana, dated Buckingham, July 10th, 1877.)—I take the liberty of addressing this letter to you, on a subject in which I have for some years been particularly interested, viz: the stratigraphical position of the economic minerals in what we have hitherto called the Lower Laurentian system of rocks.

I may briefly give you the results arrived at, after now some ten years work in Eastern Ontario and the adjoining portion of the Province of Quebec, namely, Pontiac and Ottawa counties. We find that there still exists a great *Azoic* formation, consisting of syenite and gneiss (?) without crystalline limestones. In this there are but little indications of stratification. Occasionally a limited surface presents an approach to an *obscure stratification*, but this does not appear to be due to the deposition of sediment. This rock forms the back-bone of Canada. On it there has been deposited a great series of gneisses, schists, slates, crystalline limestones and dolomites, which, although heretofore grouped with the former, is clearly distinct and unconformable. This second system contains *all of the economics* of any importance; none having been found in the old fundamental red gneiss system. All of these economics are in close proximity and have close relationship to each of the four or five great bands of crystalline limestone.

Eozoon Canadense belongs undoubtedly in the main to the

highest band of crystalline limestone yet found, although this fossil may, and indeed has been sparingly found in some of the lower limestones. The celebrated Petite Nation locality for *Eozoon*, has now heen proved to be on this highest band of limestone, and in fact in *the most recent portion of my second system;* the zone of limestone in which this fossil occurs is especially characterized by an abundance of serpentine and chrysotile. It is further traversed by veins filled with baryta and galena, and these also extend up through the Potsdam and Calciferous formations, but do not enter far into the crystalline rocks, both minerals rapidly giving out as we descend into these older rocks; while the fissures themselves narrow to threads and bifurcate. This fact has been proved by a close and careful investigation in Rossie, N. Y., and Landsdowne, Loughborough, Bedford, Madoc, and Tudor, in Canada.

Immediately beneath the *Eozoon* limestone the apatite-bearing belt of rocks comes in with horizons of both hematitic and magnetic iron ores—chiefly the former; and immediately below these again a great belt of plumbago-bearing rock (extensively wrought for this mineral in Buckingham and Lochaber, Ottawa county), an important volume of crystalline limestone filled with rust-colored lumps and beds. This band of limestone is the second in descending order. A short distance beneath this last (some twenty or thirty chains), is an important and well-marked horizon of magnetic iron ore—occasionally with layers of hematite, in which occur a number of promising mines (e. g. the Baldwin and Forsythe mines, Hull, P. Q.; the Christies' Lake and Silver Lake mines in South Sherbrooke, Lanark county, Ontario, etc.)

On a still lower horizon and close to the third belt of limestone, there is another iron ore horizon of coarsely crystalline magnetite with apatite intimately associated, which has now been identified and followed continuously for upwards of one hundred miles.

Lastly, in a still lower, fourth and last important volume of limestone, we find some large deposits of hematite iron ore (e. g. the Cowan mine in Dalhousie township, Lanark county), but these, in so far as investigated, are superficial deposits, only penetrating some fifty or eighty feet into the limestone; but the particular layer in which they occur may be followed by its deep hematite red color throughout a great extent of country.

The order then thus given to the economic minerals, just mentioned, is, in ascending order, as follows:—1st, hematitic iron ore;

2nd, magnetite and apatite (unimportant) ; 3rd, magnetite and hematite (important) ; 4th, plumbago (very extensive) ; 5th, phosphate of lime, with iron ores (an important and extensively worked belt) : and then, 6th, *Eozoon Canadense*, in abundance, with serpentine, chrysotile and veins of baryta and galena.

You will thus observe that iron ore runs through the series, though most important in one horizon ; that plumbago (with a great deal of pyrites cobaltiferous) is toward the upper portion ; while the great body of apatite-bearing rock is at the very summit.

* * * * * * * * *

The *Huronian and Hastings series of rocks* I believe to be simply an altered condition, on their western extension, of the lower portion of my *second system ;* and this alteration commences as this portion reaches Hastings county, where you will remember Hunt, Macfarlane and others likened them to the Huronian, while Sir William thought they more resembled some portions of the Devonian.—*Am. Journal.*

Preparations are being made at the Champ de Mars, Paris, for executing Foucault's pendulum experiments on an enlarged scale. His apparatus was suspended in 1851 under the dome of the Pantheon. It was in operation for a long while and removed only when the building was transformed into a church after the *coup d'état* in 1852. The weight of the pendulum will be 300 kilogrammes, and it will oscillate at the end of an iron wire from 65 to 70 metres long. Thus a special construction will be required for its suspension. The pendulum will be suspended above a grooved pipe which will move freely on an axis in its centre. The pendulum in oscillating will displace this pipe, which will remain, like the pendulum itself, fixed in space, in reference to the constellations. Underneath the pendulum will be arranged a large terrestrial globe, from 25 to 30 metres in diameter. This globe, resting on the ground, will necessarily follow with the spectators the movement of the earth. The pipe, on the contrary, supported by a pivot at the extremity of the axis, will carry large indexes, which will appear to be displaced with it. The globe, which will represent the earth, having a considerable volume, the movement of these indexes will be visible ; it will render tangible in some degree to the least attentive, the rotation of the planet on its axis.—*Nature.*

An article in the London *Times* describes some experiments which are being made at the Fulham gas-works in the lighting of lamps by electricity. The patent is that of Mr. St. George Lane Fox, the distinctive feature being an electro-magnetic apparatus attached to each lamp, and connected with a central station, at which an electric current is generated. If the experiments prove successful and the apparatus is adopted, a great saving is likely to be effected. All practical difficulties seem, however, to have been solved in America. Electricity has been tried for the purpose of lighting and extinguishing 220 street lamps in Providence, R. I., scattered over a district nine miles long. One man attends to the whole business and does it in fifteen seconds. The method has now been on trial for some months, and a saving of ten dollars per lamp per year is reported. —*Ibid.*

Col. W. H. Reynolds has concluded a contract with the English Government by which the Post Office Department has adopted the Bell telephone as a part of the telegraphic system. In a recent telephonic experiment in connection with the cable 21¾ miles long, between Dover and Calais, there was not the slightest failure during a period of two hours. Though three other wires were busy at the same time, every word was heard through the telephone, and individual voices were distinguished. This important experiment was conducted by Mr. J. Bourdeaux, of the Submarine Telegraph Company. Some very successful experiments were made with the telephone on Saturday night, between Aberdeen and Inverness, a distance of 108 miles. Songs and choruses were distinctly transmitted, and conversation was carried on at times with marvellous distinctness, notwithstanding the weather was unfavourable. The experiments were made with Prof. Bell's instruments. The Berlin correspondent of the *Daily News* states that a Berlin house is making a number of telephones for experimental use in the Russian army. The result is awaited with great curiosity in military circles. The *Cologne Gazette* denies that any telephone is in existence between Varzin and Bismark's office at Berlin. Our contemporary says that the distance, 363 kilometres, is too large for using a telephone with any advantage.—*Ibid.*

THE deepest artesian well in the world is being bored at Pesth, and has reached already a depth of 951 metres. The well at Paris, which measures 547 metres, has hitherto been the first. The work is undertaken by the brothers Zsigmondy, partially at the expense of the city, which has granted 40,000*l.* for the purpose, with the intention of obtaining an unlimited supply of warm water for the municipal establishments and public baths. A temperature of 161° F. is shown by the water at present issuing from the well, and the work will be prosecuted until water of 178° is obtained. About 175,000 gallons of warm water stream out daily, rising to a height of 35 feet. This amount will not only supply all the wants of the city, but convert the surrounding region into a tropical garden. Since last June the boring has penetrated through 200 feet of dolomite. The preceding strata have supplied a number of interesting facts to the geologist, which have been recorded from time to time in the Hungarian Academy of Sciences. Among some of the ingenious engineering devices invented during the course of the boring are especially noteworthy the arrangements for driving in nails at the enormous depth mentioned above, for pulling them out (with magnets), for cutting off and pulling up broken tubes, and. above all, a valuable mechanical apparatus by means of which the water rising from the well is used as a motive power, driving the drills at a rate of speed double that previously imparted at the mouth of the well.—*Ibid.*

THE preliminary works for boring the British Channel Tunnel are being prosecuted with great activity at Sangate. A shaft has been sunk to a depth of 100 metres, and the experimental gallery has been commenced. It is to be continued for a kilometre under the sea. If no obstacle is met with, the work will be continued without any further delay. Two powerful pumps have been established for elevating the water which, of course, filters in in large quantity.—*Ibid.*

THE Rhine Provincial Museum in Bonn has succeeded in purchasing the famous collection of prehistoric remains from the Neander Valley, hitherto in the possession of the late Prof. Fuhlrott, of Elberfeld, although a high price has been offered from England.

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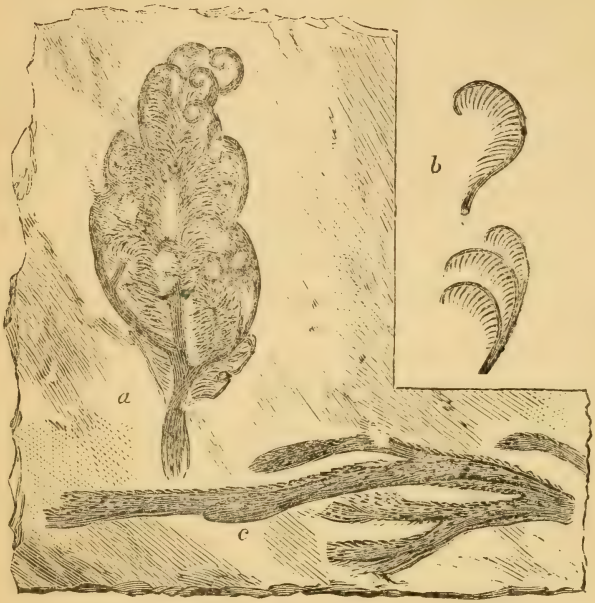

PTILOPHYTON THOMSONI.

(*a*) Impression of plant in vernation.

(*b*) Branches conjecturally restored.

(*c*) Branches of *Lycopodites Milleri*.

In this cut the parts of the fossil are given more coarsely and distinctly than in the original.

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NOTES ON SOME SCOTTISH DEVONIAN PLANTS.

By J. W. Dawson, LL.D., F.R.S., Principal and Vice-Chancellor of McGill University, Montreal.

(Read before the Edinburgh Geological Society, 20th Dec. 1877, D. Milne Home, Esq., LL.D., President, in the chair.)

Since the publication of my Memoirs on Devonian Plants, in the Journal of the Geological Society of London and in the Reports of the Canadian Geological Survey, I have watched with some interest the progress of discovery in the Devonian Flora of Scotland, and desire now to make a few remarks on new and critical forms, and on opinions which have been expressed by workers in this field.

Previously to the appearance of my descriptions of Devonian plants from North America, Hugh Miller had described forms from the Devonian of Scotland, similar to those for which I proposed the generic name *Psilophyton*; and I referred to these in this connection in my earliest description of that genus.* He had also recognized what seemed to be plants allied to Lycopods and Conifers. Mr. Peach and Mr. Duncan had made additional discoveries of this kind, and Sir J. Hooker and Mr. Salter had described some of these remains. More recently Messrs. Peach, Carruthers and McNab have worked in this field, and in the present year † Messrs. Jack and Etheridge have summed up the facts and have added some that are new.

* Journal Geological Society, London, 1859.

† Ibid, 1877.

The first point to which I shall refer, and which will lead to the other matters to be discussed, is the relation of the characteristic *Lepidodendron* of the Devonian of Eastern America, *L. Gaspianum*, to *L. nothum* of Unger and of Salter. At the time when I described this species I had not access to Scottish specimens of *Lepidodendron* from the Devonian, but these had been well figured and described by Salter, and had been identified with *L. nothum* of Unger, a species evidently distinct from mine, as was also that figured and described by Salter, whether identical or not with Unger's species. In 1870 I had for the first time an opportunity to study Scottish specimens in the collection of Mr. Peach; and on the evidence thus afforded I stated confidently that these specimens represented a species distinct from *L. Gaspianum*, perhaps even generically so.* It differs from *L. Gaspianum* in its habit of growth by developing small lateral branches instead of bifurcating, and in its foliage by the absence or obsolete character of the leaf-bases and the closely placed and somewhat appressed leaves. If an appearance of swelling at the end of a lateral branch in one specimen indicates a strobile of fructification, then its fruit was not dissimilar from that of the Canadian species in its position and general form, though it may have differed in details. On these grounds I declined to identify the Scottish species with *L. Gaspianum*. The Lepidodendron from the Devonian of Belgium described and figured by Crepin,† has a better claim to such identification, and would seem to prove that this species existed in Europe as well as in America. I also saw in Mr. Peach's collection in 1870, some fragments which seemed to me distinct from Salter's species, and possibly belonging to *L. Gaspianum*.‡

In the earliest description of *Psilophyton* I recognized its probable generic affinity with Miller's 'dichotomous plants,' with Salter's 'rootlets,' and with Goeppert's *Haliserites Dechenianus*, and stated that I had "little doubt that materials exist in the Old Red Sandstone of Scotland for the reconstruction of at least one species of this genus." Since, however, Miller's plants had been referred to coniferous roots, and to fucoids, and Goeppert's *Haliserites* was a name applicable only to fucoids, and since the structure and fruit of my plants placed them near to Lycopods,

* Report on Devonian Plants of Canada, 1871.

† Observations sur quelques Plantes Fossiles des dépôts Devoniens.

‡ Proceedings Geological Society of London, March 1871.

I was under the necessity of giving them a special generic name, nor could I with certainty affirm their specific identity with any European species. The comparison of the Scottish specimens with woody rootlets, though incorrect, is in one respect creditable to the acumen of Salter, as in almost any state of preservation an experienced eye can readily perceive that branchlets of *Psilophyton* must have been woody rather than herbaceous, and their appearance is quite different from that of any true Algae.

The type of *Psilophyton* is my *P. princeps*, of which the whole of the parts and structures are well known, the entire plant being furnished in abundance and in situ in the rich plant-beds of Gaspé. A second species, *P. robustius*, has also afforded well characterized fructification. *P. elegans*, whose fruit appears as "oval scales," no doubt bore sac-like spore-cases resembling those of the other species, but in a different position, and perfectly flattened in the specimens procured. The only other Canadian species, *P. glabrum*, being somewhat different in appearance from the others, and not having afforded any fructification, must be regarded as uncertain.

The generic characters of the three first species may be stated as follows:—

Stems dichotomous, with rudimentary subulate leaves, sometimes obsolete in terminal branchlets and fertile branches; and in decorticated specimens represented only by punctiform scars. Young branches circinate. Rhizomata cylindrical, with circular root-areoles. Internal structure of stem, an axis of scalariform vessels enclosed in a sheath of imperfect woody tissue and covered with a cellular bark more dense externally. Fruit, naked sac-like spore-cases, in pairs or clusters, terminal or lateral.

The Scottish specimens conform to these characters in so far as they are known, but not having as yet afforded fruit or internal structure, they cannot be specifically determined with certainty. More complete specimens should be carefully searched for, and will no doubt be found.

In Belgium, M. Crepin has described a new species from the Upper Devonian of Condroz under the name *P. Condrusianum*, [1875]. It wants however some of the more important characters of the genus, and differs in having a pinnate ramification giving it the aspect of a fern. In a later paper [1876] the author considers this species distinct from *Psilophyton*, and proposes for it a new generic name *Rhacophyton*. In a note he

states that Mr. Carruthers informs him that he regards *Psilophyton* as founded on the axes of *Lepidodendra* and on the fruit of ferns of the genus *Rhodea* of Stur. For this statement I have no published authority on the part of the English botanist, and it is certainly quite destitute of foundation in nature. My original specimens of *Psilophyton* are low plants with slender stems growing from *rhizomata*, and their leaves and fruits are attached to them, while *Rhodea* is merely a provisional genus formed to include certain ferns of the Hymonophyllid group, but otherwise of uncertain affinities. In the same note M. Crepin intimates that Mr. Carruthers has abandoned his *Psilophyton Dechenianum*, published in the Journal of Botany for 1843, and in which he had included Salter's *Lepidodendron nothum* and *Lycopodites Milleri* and "rootlets," as well as Goeppert's *Haliserites Dechenianus* and a peculiar plant given to him by Sir P. Egerton! * Such a change of opinion I must admit to be judicious. The fact that these plants could, even conjecturally, be identified by a skilful botanist, shows however how imperfectly they are known, and warrants some investigation of the causes of this obscurity, and of the true nature of the plants.

The characters given by Mr. Carruthers in his paper of 1873 for the species *P. Dechenianum*, are very few and general:—"Lower branches short and frequently branching, giving the plant an oblong circumscription." Yet even these characters do not apply, so far as known, to Miller's fucoids or Salter's rootlets or Goeppert's *Haliserites*. They merely express the peculiar mode of branching already referred to in Salter's *Lepidodendron nothum*. The identification of the former plants with the *Lepidodendron* and *Lycopodites* indeed rests only on mere juxtaposition of fragments, and on the slight resemblance of the decorticated ends of the branches of the latter plants to *Psilophyton*. It is contradicted by the obtuse ends of the branches of the

* Mr. Carruthers has elsewhere identified *Lepidodendron nothum* and *L. Gaspianum* with *Leptophleum rhombicum*, and this with an Australian species collected by Mr. Daintree in Queensland, but which I subsequently found to be a species allied to the well known *Lepidodendron tetragonum* of the Lower Carboniferous, and which had been previously discovered by Mr. Selwyn in the Carboniferous of Victoria. See Carruthers' paper in the Journal of the Geological Society, vol. 28, and my criticism in vol. 29, which last was however only printed in abstract, and with some comments under the head of "Discussion," to which if present I could have very easily replied.

Lepidodendron and *Lycopodites*, and by the apparently strobilaceous termination of some of them.

Salter's description of his *Lepidodendron* is quite definite, and accords with specimens placed in my hands by Mr. Peach:—"Stems half an inch broad, tapering little, branches short; set on at an acute angle, blunt at their terminations. Leaves in seven to ten rows, very short, not a line long and rather spreading than closely imbricate." These characters however, in so far as they go, are rather those of the genus *Lycopodites* than of *Lepidodendron*, from which this plant differs in wanting any distinct leaf-bases, and in its short crowded leaves. It is to be observed that they apply also to Salter's *Lycopodites Milleri*, and that the difference of the foliage of that species may be a result merely of different state of preservation. For these reasons I am disposed to place these two supposed species together, and to retain for the species the name *Lycopodites Milleri*. It may be characterized by the description above given, with merely the modification that the leaves are sometimes one-third of an inch long and secund.

Decorticated branches of the above species may no doubt be mistaken for *Psilophyton*, but are nevertheless quite distinct from it, and the slender branching dichotomous stems, with terminations which, as Miller graphically states, are "like the tendrils of a pea," are too characteristic to be easily mistaken, even when neither fruit nor leaves appear. With reference to fructification, the form of *L. Milleri* renders it certain that it must have borne strobiles at the ends of its branchlets, or some substitute for these, and not naked spore-cases like those of *Psilophyton*.

The remarkable fragment communicated by Sir Philip Egerton to Mr. Carruthers,* belongs to a third group, and has I think been quite misunderstood. I am enabled to make this statement with some confidence, from the fact that the reverse or counterpart of Sir Philip's specimen was in the collection of Sir Wyville Thomson, and was placed by him in my hands in 1870. It was noticed by me in a paper on New Devonian Plants, in the Journal of the Geological Society of London in 1871, in the following terms:—

"In his recently published 'Paléontologie,' Schimper (evi-

* Journal of Botany, 1873.

dently from inattention to the descriptions and want of access to specimens) doubts the Lycopodiaceous character of species of *Lycopodites* described in my papers in the Journal of this Society from the Devonian of America. Of these *L. Richardsoni* and *L. Matthewi* are undoubtedly very near to the modern genus *Lycopodium*. *L. Vanuxemii* is, I admit, more problematical; but Schimper could scarcely have supposed it to be a fern or a fucoid allied to *Caulerpa* had he noticed that both in my species and the allied *L. pennæformis* of Goeppert, which he does not appear to notice, the pinnules are articulated upon the stem, and leave scars where they have fallen off. When in Belfast last summer I was much interested by finding in Prof. Thomson's collection a specimen from Caithness, which shows a plant apparently of this kind, with the same long narrow pinnae or leaflets, attached, however, to thicker stems, and rolled up in a circinate manner. It seems to be a plant in vernation, and the parts are too much crowded and pressed together to admit of being accurately figured or described; but I think I can scarcely be deceived as to its true nature. The circinate arrangement in this case would favour a relationship to ferns; but some Lycopodiaceous plants also roll themselvea in this way, and so do the branches of the plants of the genus *Psilophyton*."

No figure of the plant was given, and Mr. Carruthers, if he noticed the reference, very probably did not connect it with the plant which he received from Sir Philip Egerton. His figure however, published in the Journal of Botany for 1873, leaves no room to doubt that he has had in his possession the counterpart of Thomson's specimen, of which a figure is given in this paper. My interpretation of it differs considerably from his, and as the matter is of some palæontological interest, I shall proceed to describe the specimen from my point of view.

The specimen consists of a short erect stem, on which are placed somewhat stout alternate branches, extending obliquely outward and then curving inward in a circinate manner. The lower ones appear to produce on their inner sides short lateral branchlets, and upon these and also upon the curved extremities of the branches, are long narrow linear leaves placed in a crowded manner, and which are the "tufts of linear bodies" referred to by Mr. Carruthers. The specimen is thus not a spike of fructification but a young stem or branch in vernation, and which when unrolled would be of the form of those peculiar pinnate

Lycopodites of which *L. Vanuxemii* of the American Devonian and *L. pennæformis* of the European Lower Carboniferous are the types, and it shows, what might have been anticipated from other specimens, that they were low tufted plants, circinate in vernation. The short stem of this plant is simply furrowed, and bears no resemblance to the detached branch of *Lycopodites Milleri* which lies at right angles to it on the same slab (see figure). As to the affinities of the singular type of plants to which this specimen belongs, I may quote from my Report on the Lower Carboniferous plants of Canada, in which I have described an allied species, *L. plumula*:—

"The botanical relations of these plants must remain subject to doubt, until either their internal structure or their fructification can be discovered. In the mean time I follow Goeppert in placing them in what we must regard as the provisional genus *Lycopodites*. On the one hand they are not unlike the slender twigs of *Taxodium* and similar Conifers, and the highly carbonaceous character of the stems gives some colour to the supposition that they may have been woody plants. On the other hand, they might, in so far as form is concerned, be placed with algæ of the type of Brongniart's *Chondrites obtusus*, or the modern *Caulerpa plumaria*. Again, in a plant of this type from the Devonian of Caithness to which I have referred in a former memoir, the vernation seems to have been circinate, and Schimper has conjectured that these plants may be ferns, which seems also to have been the view of Shumard."

On the whole these plants are allied to Lycopods rather than to Ferns; and as they constitute a small but distinct group, known only in so far as I am aware in the Lower Carboniferous and Erian or Devonian, they deserve a generic name, and I would propose for them that of *Ptilophyton*, a name sufficiently distinct in sound from Psilophyton, and expressing very well their peculiar feather-like habit of growth. This genus may for the present be defined as follows:—

Branching plants, the branches bearing long slender leaves in two or more ranks, giving them a feathered appearance; vernation circinate. Fruit unknown, but analogy would indicate that it was borne on the bases of the leaves or on modified branches with shorter leaves.

I would name the present species *Pt. Thomsoni*, and would characterize it by its densely tufted form and thick branches,

until specimens more fully developed shall be found. The other species will be:—

Pt. pennæformis, Goeppert, L. Carboniferous.

Pt. Vanuxemii, Dawson, Devonian.

Pt. plumula, Dawson, L. Carboniferous.

Shumard's *Filicites gracilis*, from the Devonian of Ohio, and Stur's *Pinites antecedens*, from the Lower Carboniferous of Silesia, may possibly belong to the same genus. The present specimen is apparently the first appearance of this form in the Devonian of Europe.

Mr. Salter described in 1857 * fragments of fossil wood from the Scottish Devonian, having the structure of *Dadoxylon*, though very imperfectly preserved; and Prof. McNab has proposed † the generic name *Palæopitys* for another specimen of coniferous wood collected by Hugh Miller, and referred to by him in the "Testimony of the Rocks." From Prof. McNab's description, I should infer that this wood may after all be generically identical with the woods usually referred to *Dadoxylon* of Unger (*Araucarioxylon* of Krans). The description, however, does not mention the number and disposition of the rows of pores, nor the structure of the medullary rays, and I have not been able to obtain access to the specimens themselves. I have described three species of *Dadoxylon* from the Middle and Upper Erian of America, all quite distinct from the Lower Carboniferous species. There is also one species of an allied genus *Ormoxylon*, besides the somewhat exceptional *Prototaxites*, which occurs in the Lower Erian, not far above the top of the Upper Silurian. All these have been carefully figured, and it is much to be desired that the Scottish specimens should be re-examined and compared with them.

Prof. Alleyne Nicholson has kindly placed in my hands some ancient plants which though not Scottish nor Devonian are of interest in this connection. One of these is a specimen from the Lower Ludlow of Bow Bridge. From its regular ramification, its apparently woody structure, and its traces of rudimentary leaflets, it may not improbably belong to the genus *Psilophyton*. If so, this genus occurs at about as low a horizon in Europe as in Canada.

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* Journal London Geological Society.

† Transactions Edinburgh Rotanical Society, 1870.

The remarkable plants from the Skiddaw slates described by Nicholson as *Buthotrephis Harknessi* and *B. radiata* * have also been examined by me, as well as some additional specimens from the same formation collected by Dr. G. M. Dawson. Nicholson says of the latter species:—"If its vegetable nature be conceded, it can hardly be referred to the Algae." It seems not unlikely, as Nicholson indeed suggests, that both plants may belong to the same species, and that this had the habit of growth of *Annularia* and resembled *A. laxa* of the American Devonian. If a land plant, it is probably the oldest at present certainly known.†

With these plants, Prof. Nicholson sent a fibrous body from the Upper Llandeilo of Hart Fell, near Moffat, which at first sight had the appearance of a fragment of coarse-grained wood. On microscopic examination of it, however, I concluded that it had been a bundle of spicules of a sponge of the type of *Hyalonema*. This I still believe to be its true nature.

In studying the plants of the older rocks, the botanist requires to be on his guard as to the Algæ and Zoophytes of these formations which simulate land plants. In the latter group I know no forms more deceptive than those of Hall's genus *Inocaulis*, which is regarded as a relative of the Graptolites. A specimen now before me, from the collection of Col. Grant, of Hamilton, Ontario, in its ramification and appearance of foliage, bears the closest resemblance to a lycopodiaceous plant, and I have seen what appears to be the base of a *Dictyonema* from the Niagara formation, which might readily be mistaken for a small and peculiar species of *Psilophyton*.

Messrs. Jack and Etheridge have given an excellent summary of our present knowledge of the Devonian Flora of Scotland, in the Journal of the London Geological Society. From this it would appear that species referable to the genera *Calamites*, *Lepidodendron*, *Lycopodites*, *Psilophyton*, *Arthrostigma*, *Archæopteris*, *Caulopteris*, *Palæopitys*, *Araucarioxylon*, and *Stigmaria* have been recognized.

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* Geological Magazine, Vol. VI.

† Since the above was written, Lesquereux has described supposed land plants from the Cincinnati Group (Lower Silurian) of Ohio. Saporta has discovered what he regards as a fern in rocks of similar age in France, and Claypole will shortly describe an apparently lepidodendroid tree (*Glyptodendron*) from the Clinton Group of Ohio; but neither of these is quite so old as the Skiddaw plants.

The plants described by those gentlemen from the Old Red Sandstone of Callender, I should suppose, from their figures and descriptions, to belong to the genus *Arthrostigma*, rather than to *Psilophyton*. I do not attach any importance to the suggestions referred to by them, that the apparent leaves may be leaf-bases. Long leaf-bases, like those characteristic of *Lepidofloyos*, do not occur in these humbler plants of the Devonian. The stems with delicate "horizontal processes" to which they refer may belong to *Ptilophyton* or to *Pinnularia*.

In conclusion, I need scarcely say that I do not share in the doubts expressed by some British Palæontologists as to the distinctness of the Devonian and Carboniferous Floras. In Eastern America, where these formations are mutually unconformable, there is, of course, less room for doubt than in Ireland and in Western America, where they are stratigraphically continuous. Still, in passing from the one to the other, the species are for the most part different, and new generic forms are met with, and, as I have elsewhere shown, the physical conditions of the two periods were essentially different.*

It is, however, to be observed that since, as Stur and others have shown, *Calamites radiatus* and other forms distinctively Devonian in America, occur in Europe in the Lower Carboniferous, it is not unlikely that the Devonian Flora, like that of the Tertiary, appeared earlier in America. It is also probable, as I have shown in the Reports already referred to, that it appeared earlier in the Arctic than in the Temperate zone. Hence an Arctic or American Flora, really Devonian, may readily be mistaken for Lower Carboniferous by a botanist basing his calculations on the fossils of temperate Europe. Even in America itself, it would appear from recent discoveries in Virginia and Ohio, that certain Devonian forms lingered longer in those regions than further to the North-east;† and it would not be surprising if similar plants occurred in later beds in Devonshire or in the South of Europe than in Scotland. Still, these facts, properly understood, do not invalidate the evidence of fossil plants as to geological age, though errors arising from the neglect of them are still current.

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* Reports on Devonian Plants and Lower Carboniferous Plants of Canada.

† Andrews, Palæontology of Ohio, Vol. II. Meek, Fossil Plants from Western Virginia, Philos. Society, Washington, 1875,

I trust that Scottish workers in this interesting though difficult branch of investigation, will be encouraged by the success they have already attained to still more diligent search. In collecting, the smallest and most obscure fragments should not be neglected. Such specimens, when placed in due relation to others previously obtained, may reveal the most important truths; or if by themselves unintelligible, may be rendered valuable by subsequent discoveries. The greatest care should be taken to rescue every portion of the specimens found, and to keep together those that belong to the same plant; and every fragment likely to show microscopic structure should be carefully preserved. Painstaking work of this kind will be sure to be rewarded by important discoveries; and I know by long experience that none other is likely to be successful.

TRAVELLING NOTES ON THE SURFACE GEOLOGY OF THE PACIFIC SLOPE.

By George M. Dawson, D.S., Assoc. R. S. M., F. G. S.

When on my way to resume my geological duties in British Columbia, in May last, I availed myself of the opportunity to obtain a passing glimpse of Northern California, Oregon, and Washington Territory; leaving the Central Pacific Railway, for that purpose, at Roseville Junction, near Sacramento, and travelling northward, by train and stage coach, to the extremity of Puget Sound, whence a steamer runs to Victoria, Vancouver Island. The region was a very interesting one to me, constituting the southern extension of that which I have been engaged in studying in British Columbia, and characterized in the main by the same great physical features. It is proposed now to give the substance of a few notes taken by the way, on the superficial deposits and general aspect of the country, connecting these with facts already observed in British Columbia, some of which are published in the reports of the Geological Survey, but treated of at greater length in a memoir read before the Geological Society of London, in June last. Dr. A. S. Packard, Jr., of the United States Entomological Commission, passed through the same

region, in August last, and has published some notes on the surface geology in the *American Naturalist* for November, under the title of "Glacial Marks on the Pacific and Atlantic Coasts Compared." To this article I shall again refer.

In descending the western slope of the Sierra Nevada, hard clays, packed with boulders and stones, are seen in some cuttings near Blue Canon Station (elevation, 4,693 feet) and at other places, probably as far down as Dutch Flat Station (3,395 feet). These are doubtless old moraines, due to the former glaciers of the Sierra, which, according to the American geologists who have examined this range, were at one time very extensive.

Leaving the rolling foot-hills, the train glides out on the wide and generally fertile Sacramento Plain, in the midst of which the city of the same name is situated. Near the base of the foot-hills, large areas are covered with the so-called "Hog Wallows," about which some discussion lately occurred in *Nature*, it being suggested by some that they were connected with ancient ice action. Mr. Gabb * is no doubt right, however, in attributing them to the accumulation of drifting sand and soil around clumps of vegetation, which in some cases may have afterwards perished from climatic or other causes, leaving only these peculiar hillocks to mark their former positions. The banking up of sand and soil about patches of cactus and sage is seen frequently in the dry plains east of the Rocky Mountains, as well as in Nevada, to which Mr. Gabb refers.

Leaving the main line of railway at a right angle at Roseville, and turning northward, one continues to travel over the same wide, flat, or gently undulating plain of Central California, bounded to the right by the snowy peaks of the Sierra, to the left by the more rounded summits of the Coast Range. Soon after leaving Maryville—an important town—a rugged and picturesque group of hills, called the Butte Mountains, appear on the left, some miles distant. They owe their outline apparently to prolonged atmospheric waste, and are singularly different from the dome-like summits of a glaciated country. At Reading, about 120 miles north of Roseville, the railway comes to an end, and for 275 miles, the stage coach must carry us through a country remarkably broken and tumultuous. Crossing the Sacramento by a good ferry, soon after leaving Reading, a broad,

* *Nature*, Vol. XVI, p. 183.

broken flat or plateau, with a height, according to the barometer, of 760 feet is reached. Through this little rocky hills project, and its general elevation is probably nearly that of the body of water which must formerly have filled the central "Gulf of California" for a prolonged period. The road continues to follow the Sacramento Valley in a general way for some distance, crossing first a considerable tributary, and then re-crossing the main stream. The upper part of the river is very tortuous, and flows in a deep, steep-sided valley, up which, as the road gains a considerable elevation, distant views of the snow-clad cone of Mount Shasta are, from time to time, obtained.

Leaving the Sacramento where it turns westward, we climb, by a small lateral valley, to the summit of a plateau with an elevation of about 2,300 feet, and at Strawberry Valley find ourselves apparently close to the base of Shasta. A little further on volcanic rocks are seen near the road, piled together in a way suggesting the action of a glacier. Dr. Packard, who stayed here to accomplish the ascent of the mountain, describes three small glaciers which still remain near its summit, the upper four thousand feet of which is covered with snow. These glaciers are still engaged in piling up moraines, and have left others evidencing their former extension. This mountain, at one time, must have been an important centre of local glaciation, though the phenomena of its vicinity are apparently quite distinct from those of the almost universally glaciated north.

Shasta reaches an elevation, according to Prof. Whitney, of 4,442 feet, and, in its grand isolation, and the remarkable symmetry of its conical form, is very impressive.

Leaving Shasta, the road gradually descends into the broad valley of a tributary of the Klamath River, and passing through a wide gap in a range of hills, Yreka—once an important centre of alluvial gold mining—is reached. About fourteen miles from Yreka, a flat resembling a terrace was observed skirting one of the hills, with an estimated elevation of 250 feet above the flat-bottomed valley, or about 2,775 feet above the sea.

Beyond Yreka the Klamath River is crossed, and on the line between California and Oregon the Siskiyou Range is slowly ascended, the summit on the road being, by my aneroid, 4,500 feet in height, and the actual descent from this place to the stage stable on its western base being nearly 3,000 feet.

After passing Jacksonville, situated on a branch of the Rogue

River, in a small, but fertile and beautiful valley, the main stream of the Rogue River is crossed by a good bridge. Between this river and the South Umpqua, is a rugged and irregular country, in which steep-sided hills are huddled together, but in which also several narrow but fertile valleys are concealed. The Umpqua once reached, is followed to Roseburg, whence a railway stretches to Portland, near the junction of the Columbia and Willamette rivers.

From the Sacramento River to this point all the streams crossed flow westward to the coast, transverse to the proposed Oregon and California Railway, the completion of which will be a very difficult matter. So far no traces of general glaciation, or deposits like the northern drift, have been encountered. The hills appear to have been subjected to prolonged sub-aërial weathering, the rocks, when bared on their slopes, being generally soft and decomposed at the surface. The soil covers the hills almost uniformly from base to summit, except where the slopes are remarkably steep; and is probably in most instances a product of waste of rock nearly in place. The bottoms of the valleys, though occasionally flat, and suggesting the existence of former lakes, or that the sea may at one time have flowed into them, are generelly characterized by broad coalescing fan-shaped deltas of the lateral streams. The summits and higher slopes of the hills are generally stony and gravelly, while the valleys have a clayey or loamy soil, which graduates into the former irregularly on the slopes. There is a remarkable absence of any well-marked terraces or benches; though, besides those already mentioned, a probable terrace was observed about thirteen miles above Roseburg, on the Umpqua, with an estimated elevation of 540 feet above the sea. The general impression conveyed by the country is, however, that there are no true terraces, which may arise from the fact that the region has never been flooded, or if flooded, that sufficient available material (detritus) for the formation of distinct terraces has not been at hand, or, lastly, on the supposition that the process of obliteration seen actively in progress in the somewhat similarly circumstanced dry southern interior of British Columbia, has here been so long continued as to remove almost entirely the old water marks. The hills are everywhere seamed with gullies which form the terminations of small valleys, all of which are connected, uniting as they descend toward the main stream. The almost complete absence of lakes or ponds, or

even hollows holding swamps, is very remarkable, and contrasts strongly with the innumerable lake-basins of British Columbia.* The water indeed seems never to rest from its sources in the mountains till it reaches the sea. This is either due to the prolonged action of the streams themselves in completely filling rock-basins, if such there have been, and removing all other impediments to their flow, or is the result of the original absence of those great masses of material accumulated during a stage of the glacial epoch, which in the north (as I hope elsewhere to show) have in many places been mainly concerned, at a later period, in forming lakes by the blocking of old valleys with detritus. The local colouring of the soil, in its close resemblance to that of the decomposed parts of the underlying rocks, indicating the absence of foreign material, appears also to favour the latter conclusion.

North of Roseburg the railway passes for some distance, with heavy grades and sharp curves, through a generally hilly country, crossing several branches of the Umpqua, and then reaching the upper part of the great and fertile Willamette Valley, which runs northward to the Columbia, between the Cascade Mountains with their flanking hills, and the lower ranges of the coast.

Prof. Thomas Condon, of the University of Oregon, has published some account of the state of this country in the later geological times. This I regret not to have had the advantage of reading; but, as the paper is entitled "The Willamette Sound," it would seem to imply his belief in the former submergence of this region. Prof. Le Conte indeed states that Prof. Condon has traced an old sea-margin from the coast up the Columbia River to and beyond the Cascade Range. This he compares with the sheet of nearly land-locked water which must have covered Central California at the same period. †

About two miles south of Creswell station, I noticed what appeared from a distance to be a series of pretty distinct terraces, on a hill-side, at an estimated elevation of from 100 to

* This of course applies to the region traversed, west of the Cascade Mountains. East of that range the Klamath and other extensive lakes appear on the map. These differ singularly in their form from the long river-like lakes of British Columbia, and may possibly be due to mountain elevation taking place more rapidly than the draining streams are able to lower their channels.

† Elements of Geology, 1878, p. 530.

200 feet above the road, which is here about 650 feet above the sea. The valley is wide and flat-bottomed, gradually sloping downward to the north, and quite different from any met with on the line of route since leaving the plain of central California. The soil is usually pale-coloured and often clayey, and north of Eugine, is seen in several places in cuttings to be underlain by beds with large and small rounded stones. Beyond Albany, the country is for some distance more undulating, and in many places more or less perfectly bedded deposits of gravel and sand, with occasional small boulders, occur. These much resemble some varieties of modified drift, and are probably due neither to local glaciers nor to the present or former streams, but to the transport of material by ice during a general submergence. It is here that we first meet with distinct traces of that invasion of the land by the sea during a period of cold, which has been universal further to the north.

The Willamette and Columbia Rivers, immediately below Portland, flow through a flat country, its general aspect, with that of the rivers themselves and the vegetation of their banks, being much like that of the Fraser below New Westminster. The tide affects the Willamette up to Portland. Seven miles below this place, on the left bank, very distinct terraces occur, with elevations estimated by the eye as 100, 180, and 300 feet above the river, the highest being about the general level of the surface of the country here. In several other places more or less perfect terraces appear, at various elevations, less than about 300 feet.

Leaving the banks of the Columbia at Kalama, our route continues northward between the two ranges before referred to. The only portion of the Northern Pacific Railway yet built on the West Coast, connects this place with Tacoma, 105 miles distant, and near the extremity of Puget Sound, which with a ramifying form occupies the northern part of the same great valley. The valley of the Cowlitz river is at first followed up for some distance, several small streams which afterwards unite and flow west through the Coast Range are then crossed, and in a short distance water flowing northward to Puget Sound is reached ; no strongly-marked watershed being observed. At Olequa Station, twenty-eight miles from the Columbia, is a well marked terrace or beach with an elevation of about 100 feet,*

* The elevation of places on this part of the route, though taken by barometer, were checked at the sea level at both ends, and are correct within a very few feet.

with a second about 30 feet higher. In following the Cowlitz, banks in cuttings sometimes 50 feet in height, show fine, yellowish horizontally-bedded sands. These are pretty hard, and are interbedded in places with thin and thick layers of gravel, composed of water-rolled stones, some as large as the two fists. The sandy drift exactly resembles that seen in low banks near the water level on the Willamette and Columbia, but as we go northward, and ascend, the gravelly layers continue to increase in importance. Forty miles from the Columbia the railway passes over a distinct and wide bench with an elevation of 337 feet, the general level of the country—which is here nearly flat—being about 380 feet. Gravel beds are abundant at Centreville (54 m.) with a general elevation of about 160 feet. Here the rolled gravel of the subsoil contains some small boulders up to ten inches in diameter. At 65 miles from our initial point, elevation 230 feet, boulders two feet in diameter are first seen, and a few miles further northward gravelly banks are found, of rudely mingled coarse materials, including boulders up to three and four feet in diameter, with overlying or interstratified layers of fine yellowish sand. The country here becomes undulating, with many low ridges and hillocks, and *begins to show small ponds and swamps.* A few miles south of Yelm Prairie (74 m., elevation 295 feet), some ridges, in their composition resemble the closely-packed gravel and boulder deposits of Spring Ridge and Beacon Hill near Victoria. From this point to Tacoma, the county is generally flat or gently undulating, and declines gradually toward the head of the Sound, the superficial deposits being in general not so coarse as those just described.

At Tacoma, the banks along the shore show a great thickness of firm finely-bedded sandy and clayey deposits, which form the substratum of the plateau above, but which I had not time to examine. At Seattle—the centre of the coal mining industry—about 30 miles northward on the east shore of the Sound, the drift consists of sands, gravels and clays, without any apparent regular sequence, but with occasional large and many small boulders scattered through them. The sands are frequently current-bedded, and in one place curiously contorted layers of fine, hard, clayey sand, alternated with others nearly horizontal, as though floating ice had from time to time disturbed the regularity of the deposit. Some beds resemble in all respects true boulder-clays, being thickly packed with large and small stones,

which lie in all positions. These beds, however, seem to form a part of the general series, and do not appertain specially to any particular horizon. No clearly glaciated stones were seen, though from the shape and appearance of many, it is probable that a careful search would bring such to light, as at Victoria. Fine exposures of drift also occur at Port Townsend near the entrance to the Sound, and elsewhere along its banks.

The drift deposits of Puget Sound, as a whole, very much resemble those of the southern part of Vancouver Island and shores of the Strait of Georgia further north, which are described in the paper above referred to. There is good evidence to show that at one time a great glacier-sheet, fed both from the mainland and mountains of Vancouver Island, filled the whole Strait of Georgia, and passing southward, overlapped the low south-eastern corner, at least, of Vancouver Island. It would also appear that when this glacier began to retreat, the sea was at a level considerably higher than at present, and that as soon as the heavily-glaciated rocks of the lowlands were uncovered, the drift deposits—boulder clays, gravels and sands—were laid down on them. These are found in some places near Victoria to include marine shells. From a careful examination of the south-eastern corner of Vancouver Island, my impression is that its glaciation though heavy, was not long continued, and it is probable that in this case the front of the glacier did not at any time reach far southward into the low country of the Sound, or westward along the Strait of Fuca. Be this as it may, however, it is pretty evident that during the submergence above referred to, the great valley, including the Sound, and country to the south, of which the drift deposits have just been described, was a wide strait; along the margins of which local glaciers may have discharged in some places, and in which sea currents, aided by debris-bearing icebergs and coast-ice piled up the deposits now found. It is probable that the same sheet of water passed yet further southward, forming the Willamette Sound, of Condon, with a wide opening to the open ocean by the valley of the Columbia River. If the Strait of Fuca was not at this time encumbered by glacier ice, the high Olympic mountains of the north-western corner of Washington Territory must have formed a snowy sea-washed island.

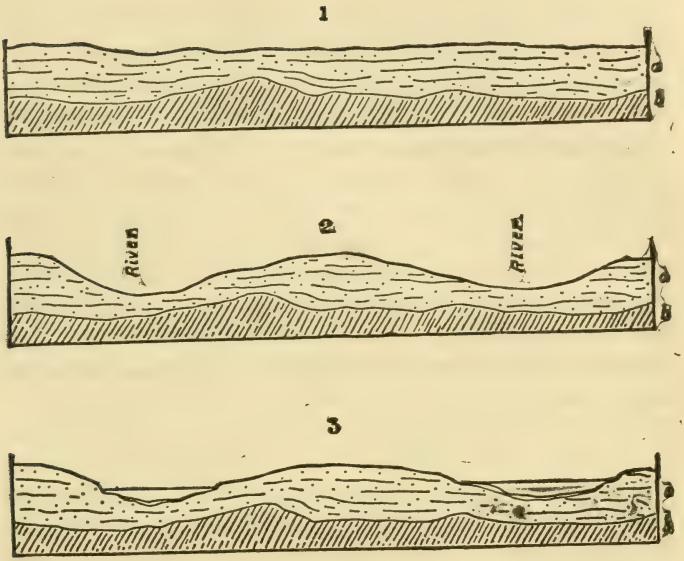
No great mass of glacier ice can have excavated the present channels and water-ways of Puget Sound, as a glance at their

complicated form on any good map will show; nor do the circumstances allow them to be accounted for by the excavating action of systems of local glaciers. If, however, the Strait of Georgia ice-sheet ever traversed the low country now occupied by the Sound, it may have planed and levelled it to some extent.

Mr. George Gibbs has described the passages and inlets of Puget Sound as excavated in many places in drift deposits, which appear not only to form their present banks, but to underlie their beds. Guided by the general form of the inlets, and this description, I ventured in a note on some of the more recent changes in level of the coast of British Columbia and adjacent regions, printed in the *Canadian Naturalist* for 1877, to suggest that they were cut out by rivers during a post-glacial elevation of the land, and afterwards filled up by sea-water on its depression to the present level.

Though aware of the danger of generalising hastily for a region which has not been thoroughly examined, I now venture to again advance this idea with somewhat greater confidence. In their outline on the map, these inlets resemble the fjords with which the whole coast north of the forty-ninth parallel is dissected, but the latter penetrate into the heart of a rugged and mountainous country, and though they may have been cleared of drift material during a post-glacial elevation, have probably been excavated in the hard rocks of the Coast Range of British Columbia during a prolonged period in the later Tertiary, when the land was at a high level. The canals of the Sound are excavated in a low drift-encumbered country, based on soft Tertiary rocks, which, owing to the thickness of later deposits are seldom seen. The average height of the surrounding drift-plateau is from 180 to 200 feet. The channels are deep—often over 100 fathoms—but not uniformly so, as shallower bars cross them in many places which would give rise to a series of great lakes if reelevation should now occur. Here bars, like those so often found near the entrance of the fjords to the north, are generally in observable connection with their cause, in the opposition of tidal currents, the slackening of these currents as they enter wider channels, or other circumstances bringing about the deposition of suspended sediment. They are probably due to the most modern period. In the wide flats surrounding the mouths of streams and rivers, near the present water level, we have evidence of the comparative permanence of the present relations of sea and land.

To recapitulate, a wide hollow deeply scored by rivers, probably extended from the south of Vancouver Island to the Columbia, in later Tertiary times. The northern part of this, now occupied by Puget Sound, may or may not have been planed down by an ice-sheet, but was deeply filled and levelled up with drift during the glacial submergence and retreat of the great glaciers. Being afterwards elevated to a height possibly 600 feet or more greater than the present, streams again began to excavate their channels, guided no doubt in the first instance by such ill-defined longitudinal hollows as the sea-currents, flowing north and south, had before formed. This action continued long enough for the production of deep and wide river valleys in the drift deposits, and in some cases in the more prominent parts of the underlying Tertiary rocks. Lastly, a resubsidence to the present stage having occurred, the sea water filled the river valleys, of which the gently-sloping sides soon became eroded at the water-line into sea-cliffs, and tide flats were formed at the mouths of the streams and wherever ditritus was abundant along the shores.



Diagrams illustrating stages in the production of the Inlets and Passages of Puget Sound.

No. 1. Eroded (perhaps glacier-planed) surface of the Tertiary rocks (*b*) covered uniformly with drift material (*a*) at the close of the glacial epoch.

No. 2. Wide and deep valleys cut into the drift deposits by streams. Land standing at a greater elevation than at present.

No. 3. Valleys filled by the sea owing to subsidence. Shore cliffs and recent submarine deposits in course of formation.

ON SOME JURASSIC FOSSILS FROM THE COAST RANGE OF BRITISH COLUMBIA.

By J. F. Whiteaves.

The fossils which form the subject of the present paper were collected by Mr. G. M. Dawson at three localities in British Columbia during the summer of 1876. By far the greatest number of specimens are from the left bank of the Iltasyouco River, four miles above its junction with Salmon or Dean River; two are from the falls of the Iltasyouco, three miles below the last mentioned locality, the rest are from Sigutlat Lake. The Iltasyouco River, it may be mentioned, is a stream about six miles in length, which flows from Sigutlat Lake into the Salmon River, which it joins in Lat. 52° 53′ and Long. 126° 15′ approximately. The geological structure of the district and the lithological characters of the rocks are described by Mr. Dawson in the Report of Progress of the Geological Survey of Canada for 1876–77, now in course of publication, for which these notes were originally written. The collection consists of twenty-seven species of Mollusca and one of Annelida. With very few exceptions, the fossils are both imperfect and in a poor state of preservation, so that their generic position even is sometimes doubtful. The Ammonites, in particular, are almost all mere fragments. The following is a provisional list of the species, with short descriptions of such as appear to be new, and critical remarks on others.

1. *Terebratula* ——?—Shell (or rather cast) compressed, very gently convex; outline ovate or obovate; length greater than the width at all stages of growth; thickness through the closed valves about equal to one half the width; no mesial fold or sinus. The shape varies in different individuals; the maximum width being nearly always in advance of the middle, but one specimen is broadest at a little distance from the hinge line and somewhat pointed in front. Two half grown examples are ovately-orbicular, and not longer than wide, but the rest are much more elongated. Beak of the ventral valve incurved (but scarcely so much so in the cast as to entirely conceal the delti-

dium or beak of the dorsal valve); obliquely and concavely truncate; foramen rather large; lateral ridges distinct. Dorsal valve with an impressed line or groove in the centre, which extends nearly half-way to the front margin, and indicates the position and shape of the mesial septum; on either side of this there is a single (?) divergent muscular scar, of nearly the same length. The shape of the scars is subspathulate or elliptic-ovate, but they each commence as a simple impressed line. Surface marked with coarse, distant, concentric striæ or plications.

Sigutlat Lake and Iltasyouco River, abundant.

The only Terebratula yet recorded from rocks which are known to be of Jurassic age in North America, is described and figured by Meek, though without any specific name, in the first volume of the Palæontology of California. It was obtained on the western slope of the Sierra Nevada, and appears to be distinct from the present species, as it (the Nevada shell) has a more globose form and a short mesial fold and sinus. An ovate, elongated Terebratula occurs in the coal-bearing rocks of the Queen Charlotte Islands, in beds which may be Jurassic, but young specimens from the last mentioned locality are much wider than long, which is not the case with any of those collected by Mr. Dawson. In the absence of any knowledge of the test of this species, it is very difficult, and indeed almost impracticable to separate it by any valid character from some European Terebratulæ, such as *T. ovoides*, Sowerby, and *T. punctata*, Sowerby (including *T. subpunctata*) as described and figured by Davidson; more especially from the first of these.

2. *Gryphæa calceola, var Nebrascensis*, Meek & Hayden. Iltasyouco River, one typical and characteristic convex valve, with the test preserved, showing both the internal and external surface markings; also an exfoliated specimen with both valves in situ, and a few casts.

3. *Camptonectes* (*?*) *extenuatus*, Meek & Hayden. A cast of the convex valve of a small Pecten from the Iltasyouco River, precisely similar to the specimen figured under the above name on Plate III. (fig. 6), of the "Palæontology of the Upper Missouri." The surface markings of *C. extenuatus* are unknown, as is also the shape of its ears, and its generic position too is quite problematical, though its aspect is more that of a *Syncyclonema* than of a *Camptonectes*. Casts of the flat valve of a thin compressed Pecten are rather frequent in the Iltasyouco

River porphyrite, which may belong to the same species. These are strikingly like *Syncyclonema Meekiana*, from the Queen Charlotte Islands, in the condition in which that fossil is most commonly obtained, but the exterior of the test of the convex valve of *S. Meekiana* is known to be both closely and nodosely cancellated.

4. *Lima duplicata*, Sowerby (Sp). Two left valves of a Lima both from Sigutlat Lake, which if not identical with the *Plagiostoma duplicata* of the "Mineral Conchology," are remarkably like it in shape, and so far as can be ascertained at present, in sculpture also. One specimen has the test partly exfoliated; in the other the shell is considerably decomposed, but its original surface markings are sharply impressed on part of the rock which was broken from the specimen, and which originally enveloped most of one side of it. The sculpture consists apparently of about twenty-eight acute, angular, radiating costæ, each of which alternates with a single, fine, raised line, just as in *L. duplicata*.

In the Quarterly Journal of the Geological Society of London for 1866 (Vol. XXII., p. 82) Mr. Tawney has described a species with very similiar shape and style of ornamentation, from the Lower Lias of South Wales, under the name *Lima subduplicata*. Mr. Charles Moore, however, in a paper on "Abnormal Secondary Deposits," published in the Journal of the same Society for the following year, places *L. subduplicata* as a synonym of *L. duplicata* on page 509, though on page 530 of the same paper it is said to be identical with *L. dentata* Terquem, which is admitted to be distinct from *L. duplicata*. It may be, therefore, that more than one species have been confounded under this name, but if not, few if any Mesozoic molluscs have a wider range in time than *L. duplicata*. Originally described from the Coralline Oolite of Yorkshire, it is abundant in the Cornbrash, Forest Marble, Great and Inferior Oolite of many parts of England, as the writer can testify from direct observations in the field. Munster says it is found in the Lias of Germany associated with *Rhynchonella rimosa*, and Goldfuss mentions it as occurring in the Inferior Oolite of Hanover and Brunswick. It is included by Rev. P. B. Brodie in a list of Lower Lias fossils from near Wells, (Somerset), also by Mr. C. Moore, in lists of species from the same formation in South Wales, and from several localities in Somersetshire in the zone of *Ammonites Bucklandi*.

5. *Inoceramus*——(?) Falls of the Iltasyouco River, a fragment only of a species with wide, rounded, concentric folds. Mr. Dawson made a rough sketch of the specimen as it originally appeared in the rock, and, judging by this, the shell appears to have been very similar to the *Inoceramus venustus*, Sowerby, of the English Lias.

6. *Eumicrotis curta* (?) Meek & Hayden. Iltasyouco River, two imperfect right valves, both marked with distinct raised lines. Almost certainly indentical with *Monotis substriata*, Munster, as suggested by Meek. Stoliczka has shown that Beyrich's generic name *Pseudomonotis* has two years' priority over *Eumicrotis* Meek, so that the name of this shell ought probably to be written *Pseudomonotis substriata*, Munster, Sp.

7. *Pteroperna*——(?) Two specimens of a smooth, oblique and elongated species of *Pteroperna*, with a long and deeply emarginate posterior wing, both from the Iltasyouco River; probably new to science, but not in a sufficiently good condition to be properly characterized.

8. *Pinna subcancellata*, N. Sp.—Shell moderately convex, wedgeshaped, elongated: squarely truncate behind, or nearly so; hinge line straight; ventral margin also straight for the greater part of its length, but rounded at its junction with the posterior end. Surface marked by coarse, irregularly and unequally disposed concentric plications, which, in the upper two-thirds of the shell, are crossed by about eighteen radiating, but nearly longitudinal raised lines. The amount of convexity of the valves cannot be precisely defined, as the only specimen yet obtained is distorted by pressure. Falls of the Iltasyouco River, a solitary example with both valves *in situ*. The beaks are broken off, but the sculpture of both sides of the fossil is well shown. Perhaps only a variety of *Pinna Hartmanni*, Zieten, from which it differs in being more squarely truncated at the anal end, and in having the radiating costæ confined to the upper two-thirds of the shell.

9. *Modiola formosa* Meek & Hayden. One very good specimen from Sigutlat Lake. Very near to *M. cancellata*, Goldfuss.

10. *Modiola pertenuis*, Meek & Hayden. Three left valves of a small, smooth Modiola, (two from the Iltasyouco River, the other from Sigutlat Lake), one of which appears to be a distorted but otherwise tolerably typical example of *M. pertenuis*, while the two others are probably only a short, broad

variety of the same species. It is not easy to see how *M. pertenuis* can be distinguished from *M. minima*, Sowerby, of the European Lias, as figured and described in the Mineral Conchology and by Goldfuss.

11. *Grammatodon inornatus*, Meek & Hayden. Iltasyouco River, two single valves. Apparently very near to *Arca Lineata* Goldfuss, from the Lias of Germany.

12. *Grammatodon (?) Iltasyoucoensis*, N. Sp.—Shell moderately convex, but slightly depressed near the middle below; very inequilateral; anterior end short, narrow and obtusely pointed; posterior end elongated, widening gradually both above and below; truncated almost squarely at its extremity. Hinge line straight, ascending gradually behind the beaks, and sloping downwards rather abruptly in front of them. Beaks broad, depressed, curved inwards and forwards, situated very near to the anterior end, but not quite terminal. Right valve (the only one known) with indications of one or two elongated, linear posterior teeth, placed parallel to the hinge line, and of at least three obliquely transverse anterior teeth. Surface marked with close-set, crowded and extremely fine, radiating striæ, which are scarcely visible to the naked eye, and which become almost obsolete on the ill-defined posterior area.

Iltasyouco River, a single specimen of the right valve, with the lower half of the posterior end broken away. The pallial line and muscular impressions are not visible, and the hinge characters are imperfectly shown, so that it is doubtful whether this shell is a *Grammatodon* or a true *Macrodon*.

13. *Cucullæa (?)* Sp. Undt.—A small, rather ventricose, subrhomboidal species, with prominent, nearly central, incurved beaks. An obtuse keel runs from the beaks to the base, and separates an obliquely flattened posterior area from the main body of the shell. The surface is marked by close-set, raised striations, which are crossed by rather more distant, radiating lines.

14. *Yoldia* (or *Corbis*) Sp. Undt.—A single valve of a small shell from the Iltasyouco River, with no vestiges of the hinge teeth or of any of the markings of the interior remaining. The outline of the specimen is remarkably like that of *Nucula speciosa*, Munster, from the Muschelkalk of Germany, which is probably a *Yoldia* or *Portlandia*, but it is also almost equally similar in its shape to *Corbis uniformis*, Phillips, from the

Yorkshire Lias. It is not a *Tancredia*, in the writer's judgment, though its contour is not very dissimilar to a fossil doubtfully referred to that genus by Meek and Hayden, under the name *T. inæquilateralis;* but the latter species has a much flatter shell, and is more angular at the junction of the hinge line with the posterior end.

15. *Trigonia Dawsoni*, N. Sp.—Shell gently convex, compressed; outline ovately-subtrigonal; anterior end very short, broadly rounded, as is also the ventral margin; beaks elevated, recurved, anterior, subterminal; hinge line sloping concavely downwards behind the beaks; extremity of the somewhat elongated posterior end truncated rather obliquely. Surface of the main body of the shell marked by about twelve curved, nodulous costæ, all of which commence at the margin of the posterior area. The five nearest the beaks curve downwards, and terminate at the anterior end. The middle ones, though curved, are nearly transverse, and end at the centre of the ventral margin, while the three last incline decidedly backwards. The posterior area is marked either by crowded, transverse, regularly arranged and continuous raised striæ, or by coarse, irregular and broken up or angularly bent, short, transverse folds. Iltasyouco River and Sigutlat Lake, frequent and well preserved. A well marked and characteristic species, which the writer has much pleasure in naming after its discoverer, Mr. G. M. Dawson. It would appear that *T. Dawsoni* occurs also in the Jurassic rocks of the western slopes of the Sierra Nevada, for on page 49 of Vol. I of the "Palæontology of California," after describing *Trigonia pandicosta* from that locality, Mr. Meek says:—"there are in the collection fragments of apparently two other species of this genus. One of these is considerably larger than that described, and has the costæ distinctly nodose. They are, however, not angularly deflected, but curved gradually forward."

16. *Astarte ventricosa*, Meek. Iltasyouco River, three or four rather imperfect specimens, whose specific characters are obscurely shown, and whose identification is, therefore, somewhat uncertain. They vary considerably in shape, two being rather longer than wide; in the others the height and length are nearly equal. The pallial border of the test is distinctly crenulated.

17. *Astarte fragilis*, Meek & Hayden. A badly preserved specimen of an Astarte, from the Iltasyouco River, which although much larger than the type of *A. fragilis* from Dakota,

and more convex on the posterior part of the hinge margin, is probably referable to that species.

18. *Pleuromya subelliptica*, Meek & Hayden. Six or seven specimens of an elongated, nearly smooth *Pleuromya*, from the Iltasyouco River, which, though very variable in shape, on the whole agree tolerably well with Meek and Hayden's description of *Myacites subellipticus* from the Black Hills, much better in fact than they do with the figures of that species. *M. subellipticus* is said to be very similar in shape and sculpture to *Panopœa peregrina*, D'Orbigny, from the Oxfordien beds of Russia, and so are some of the Iltasyouco River *Pleuromyœ*, but the latter, in shape at least, are equally like some forms of *P. Terquemea* Buvignier as figured by Agassiz under the name *P. tenuistriata*, but in that shell the concentric striations are much more numerous and regularly arranged than they are in the specimens collected by Mr. Dawson.

19. *Pleuromya unionides*, Rœmer, Sp. Six casts of a ribbed Pleuromya, (one from Sigutlat Lake, the others from the Iltasyouco River), which have been carefully compared with Goldfuss' and Agassiz's descriptions and figures of the above mentioned European Liassic species, and which do not appear to be separable from it even as a local variety. The Sigutlat Lake specimen, and three of those from the Iltasyouco River are much distorted, and have their original shape much altered by pressure, but two from the latter locality seem to have retained their normal form. *Pleuromya Carlottensis*, from the Queen Charlotte Islands, has a shorter, higher and more ventricose shell; its beaks are more elevated and curve forwards as well as inwards; its posterior extremity, too, is more pointed. *P. Carlottensis* is, perhaps, synonymous with *P. Alduini*, Bngt. (Sp.) of the European Jurassic.

20. *Planorbis veternus*, Meek and Hayden. While breaking a large piece of the Iltasyouco River porphyrite containing a valve of *Gramatodon inornatus* and a cast of the shell supposed to be referable to *Pleuromya unionides*, the writer was so fortunate as to obtain a perfect specimen of this shell, *in situ*, in one of the fragments. *Planorbis veternus*, and three other species of fresh water shells, were first found in loose pieces of rock at the base of the Black Hills in Dakota, and some doubt previously existed as to the true geological horizon of these fossils. Writing in 1864, Mr. Meek says, "they may possibly be Tertiary

species, but differ from all those we have seen from rocks of that age in the North West. It is only provisionally we place them along with the Jurassic forms." The finding of *P. veternus*, in place, associated with fossils that are almost undoubtedly Jurassic, make its age tolerably certain, and strikingly confirm Mr. Meek's conclusions. Mr. Moore has described another species of Planorbis, (*P. Mendipensis*), from the Charter House Liassic lead mine in the Mendip Hills of Somerset, in rocks of a very similar geological horizon.

21. *Stephanoceras Humphreysianum*, Sowerby, Sp. Sigutlat Lake, one specimen, the only tolerably perfect ammonite in the collection. Prof. A. Hyatt, to whom all the ammonites were sent for examination, says of this fossil,—"If found in Europe it would be unhesitatingly referred to this polymorphic species and identified with the typical forms."

22. *Stephanoceras Braikenridgii* (?)—Sowerby, Sp. Iltasyouco River, two small fragments. "These are very interesting fragments, with all the marks of the mature forms of *Steph. Braikenridgii*, but ought to be queried because the young characteristics are not visible."—Hyatt.

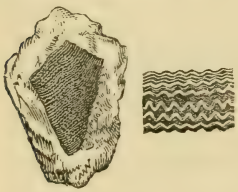
23. *Stephanoceras*——(?) Seven fragments of a small *Stephanoceras*, from the Iltasyouco River, which Prof. Hyatt has compared with European specimens, and pronounces the former to be closely allied to *S. Gervillei* (*Ammonites Gervillei*, Sowerby) and *S. Platystomum*, Reinecke, (sp.) but adds that the young look rather like the early state of *S. macrocephalum* or *S. Herveyi*. The penultimate whorl is rather finely ribbed, and the outer surface of the body chamber is quite smooth, at least in the cast; the umbilicus is not distinctly shown, but it must have been exceedingly small. The shape of the lip is indicated to a certain extent by an obliquely transverse, slightly flexuous, incised groove, which curves forward from the umbilicus, and is produced into a bluntly pointed, beak-like process in passing over the periphery.

24. *Perisphinctes anceps?* Reinecke, Sp. Iltasyouco River, a solitary fragment, which, according to Prof. Hyatt, "has the peculiar abdominal ribs and knob-like spines of *P. anceps*. The abdomen may have been channelled, and, if so, the above identification could be given without the query."

25. *Belemnites?*——Seven or eight imperfect specimens of a Belemnite with an exceedingly slender parallel-sided guard.

These are in such a bad state of preservation that it would be a hopeless task to try and identify the species, or to describe it with sufficient accuracy if new. At the commencement of the phragmocone, the largest example does not measure quite three lines in diameter, while several of the specimens would lie loosely in the cavity of a wheaten straw. The surface of the whole is so much worn that it is impossible to tell whether there was a median or an apical groove, or none at all. Iltasyouco River.

26. *Belemnites (?)*—— At the same locality as the preceding shell, and associated with it, are portions of what seems to be either another species of Belemnites, or at least a different varietal form, and unfortunately, in quite as bad a state of preservation. The guard, though elongated and narrowly cylindrical in shape, is much thicker and more conical than is that of the fossil last described, and it is not improbable that the present species may prove to be conspecific with a Belemnite fron Dakota, supposed by Meek and Hayden to be a slender variety of their *Belemnites densus*, and figured on Plate V. (figs. 1 a, 1 b, 1 c,) of the "Palæontology of the Upper Missouri." Detached phragmocones, probably belonging to both species, are not unfrequent also at the Iltasyouco River. These, though not very well preserved, appear to show that the fossils of which they formed a part are referable to *Belemnites* proper and not to *Belemnitella*.



27. The nature of the curious fragment represented in the wood cut is uncertain, but it may have been a portion of an *Aptychus*, a fragment of the pen of a calamary allied to *Teudopsis*, or a piece of an aviculoid shell.

28. *Serpula*—— (?)—Three casts of the shelly tube of a species of Serpula. The most perfect specimen has been secreted by the animal on nearly the same plane, and is twice bent, so as to present the appearance of a flexuous-sided triangle with the angles blunted and half of one of the sides wanting. The others are simply flexuous, and no vestige of the test or of its surface markings is preserved on any of them. Locality, Iltasyouco River.

The fossils above enumerated are of much interest as affording the first instance yet observed of the occurrence of a well marked fauna of Jurassic age in British Columbia. It is true that fossils,

probably from a very similar geological horizon, were collected by Mr. Selwyn in 1875, at Rock Island Gates below Hudson's Hope on the Peace River, but the specimens, which were described in the Report of Progress for 1875-6, are very few in number, and so imperfect that none of the species could be satisfactorily determined.

If the identifications in the present paper be correct, it would appear that nine of Meek & Hayden's species from the Jurassic rocks of Dakota, are found also in the Coast Range of British Columbia. These are:—

Gryphœa calceola, var., *Nebrascensis.*
Camptonectes extenuatus.
Eumicrotis curta.
Modiola (Volsella) formosa.
" " *pertenuis.*
Grammatodon inornatus.
Astarte fragilis.
Pleuromya subelliptica.
Planorbis veternus.

It would seem, therefore, that the sea of the Jurassic epoch once covered an extensive, and probably contiuuous tract of country on the western portion (at least) of this Continent; and there are strong reasons for supposing that the marine faunæ of the Triassic and Cretaceous periods were no less widely spread. The Upper Trias is known to extend from Mexico, through California and Nevada, to British Columbia, and *Monotis subcircularis*, Gabb, one of its most characteristic fossils, has recently beeen found in the northern part of Vancouver Island; also, on the mainland of British Columbia, at a few miles from Fossil Point, on Peace River, and on Upper Pine River, east of the mountains.* Two species of fossils which were originally described from the Cretaceous rocks of Texas, have been found by Mr. Selwyn in deposits of the same age on the Upper Peace River, and among the extensive collections of Cretaceous fossils obtained by Mr. Richardson from Vancouver and adjacent Islands, there are several species which occur also in Texas, Nebraska or New Jersey. From these, and from similar circum-

* The last mentioned locality, represented by specimens collected for Mr. Dawson by Mr. J. Hunter, of the Railway Survey.

stances, it seems highly probable that nearly the whole of North America must have been submerged during the deposition of the later portion of the Cretaceous series. It has been supposed, indeed, that towards the close of the Mesozoic period the Rocky Mountains formed a land barrier between two oceans, each of which was tenanted by a distinct local fauna, but this hypothesis is not borne out by the facts of the case as we now know them, and the existence of Cretaceous rocks at very high elevations both in the Cascade range and in the Rocky Mountains, goes far to prove that some of the loftiest peaks of these two mountain chains owe their elevation to movements of Post Cretaceous date.

Trigonia Dawsoni and *Astarte ventricosa*, fron the Iltasyouco River, are also found in the Jurassic rocks of the western slope of the mountains in Nevada; and it may be that there is no physical or geological break between the coast range of British Columbia and the Sierra Nevada. Mr. Gabb has pointed out that the Jurassic fossils of Nevada are probably of the age of the Lias, and some of the Iltasyouco lamellibranchs, as has already been stated, are barely distinguishable from European Liassic species. On the other hand, the few Ammonites collected by Mr. Dawson, so far as very fragmentary specimens enable one to judge, appear to be conspecific for the most part with well known forms from the English Inferior Oolite, though one, which has been doubtfully referred to *Perisphinctes anceps*, may indicate an horizon as high as the Oxford Clay or Coral Rag. On the whole, however, the evidence, as far as it goes, is in favour of the supposition that these fossils from British Columbia belong to the lower rather than to the upper part of the Jurassic series.

NOTES ON THE LOCUST IN THE NORTH-WEST IN 1876.

By George M. Dawson, D.S., Assoc. R. S. M., F.G.S.

Having collected and published in the *Naturalist*, notes bearing on the appearance and movements of the locust, or devastating grasshopper, in Manitoba and the North-west Territory in 1874 and 1875; I propose briefly to put on record information obtained for 1876. The insect having drawn upon itself the attention of the western farmer, has at last become the subject of investigation by a Scientific Commission appointed last year by the Government of the United States. With the intelligent co-operation of the farmer, we are likely soon to know all that can be known about the locust, and what may be done to prevent its destructive increase.

Absence on the West Coast, and the pressure of other business, with the long time necessarily occupied in communicating with some parts of the far west, have prevented the earlier appearance of these notes.

Fortunately for the Province of Manitoba and the North-west Territory, the history of the movements of the locust within their limits in 1876 is not a long one. In 1875, as chronicled in the *Naturalist*, the locust hatched abundantly in Manitoba and its vicinity, and also in considerable numbers in the country near the foot of the Rocky Mountains. The swarms of Manitoba flew southward, while a great invasion of winged swarms *from* the south, occurred in the region west of Manitoba, where eggs were extensively deposited. From these eggs, with those which any small colonies of locusts remaining as residents in the country may have deposited, the swarms of 1876 were produced. No invasion of the region north of the 49th parallel from the south, occurred, except in the extreme west, where at Fort Walsh, flights are reported as arriving from Montana in the middle of July.

Over the greater part of the area defined northward by the 52nd parallel, and extending from the Rocky Mountains eastward to the 100th meridian, important hatching grounds were

scattered. These appear to have been specially numerous in the valley of the South Saskatchewan, as it is reported to have been owing to the destruction of the grass by the locusts that the northern herd of buffalo was forced so much further east than usual in 1876. True to their instincts, the broods, on arriving at maturity, flew southward and south-eastward, forming with additions from south-western Manitoba, and parts of Colorado, Wyoming and Dakota, the great army which overspread the Western States.

In the summer of 1876, the cultivated lands of Manitoba were threatened with locust invasions from two quarters, from both of which dangers they, however, fortunately escaped. The great hordes produced in the north-west might have overspread and devastated the province, as they have formerly done on several occasions. These, however, swept past by its western boundary and going southward, arriving in many of the south-western states too late to do much damage; whereas, had they visited Manitoba the loss would have been very great, owing to the less advanced condition of the crops. In south-western Minnesota locusts have bred annually since 1873, according to the reports of Mr. A. Whitman and Dr. Riley. In 1876 considerable swarms were produced, and these, on reaching maturity, set out on a migration to the north and north-westward, and might well have reached Manitoba. The determination of the locusts to move in this direction was evidenced (as has often before been noticed) by their waiting for favourable winds. They were, however, continually repulsed, and eventually borne back by the winds to their hatching places, and thence south and south-west to Iowa and Nebraska.

In an interesting article by Dr. Riley on the "Rocky Mountain Locust," in part reprinted in the last number of the *Naturalist*, I am glad to see that the preservation of the dry prairie grass in autumn and its firing, for the purpose of destroying the young insects in their breeding grounds in the far west, is warmly advocated. This was suggested in my notes on the invasion of 1874, and may yet, I believe, be carried out with good result.

Dr. Riley, in his valuable work on the Locust,* is in error with regard to the northern range of the insect, as represented in his coloured maps, especially that facing the title page; where

* The Locust or Grasshopper Plague, Chicago, 1877.

the areas designated as *frequently visited*, and *permanent breeding grounds* are made, together, to cover a breadth of about twenty degrees of longitude in the north, and to run beyond the 60th parallel of north latitude. The range of the locust is really limited to the north by the southern margin of the forest-clad country, and may be roughly defined by a line nearly as follows:—From the intersection of the 96th meridian and 49th parallel of latitude, to the south end of Lake Winnipeg, thence to Manitoba Lake, and following this lake and Winnipegosis Lake; from the north end of the latter westward to the Forks of the Saskatchewan, and thence nearly following the course of the Saskatchewan till the wooded country at the base of the Rocky Mountains is attained. It is not meant to affirm that single specimens of *Caloptenus spretus* may not be obtained beyond this limit, or even that small colonies may not exist from time to time; but the edge of the northern forest, with its climatic accompaniments, seems to constitute an absolute barrier to the destructive abundance of the insect. Further north, in the Peace River country, where prairies and tracts of lightly wooded land are extensive, I cannot learn, — though careful enquiry has been made on the subject, — that the locust swarms have ever been seen. At nearly all the Hudson Bay Company's posts more or less cultivation is carried on, and some record would have been kept of the appearance of the locust, had it occurred. Mr. S. D. Mulkins, of Battleford, to whom I wrote on this subject, says:—"From all the information I can collect, I cannot find that the grasshopper has ever visited any of the Hudson Bay Company's posts north of latitude 53° I have never heard that they have ever penetrated to the Peace River country. To do so they would have to cross a wide belt of pine forest. Whether it is the scarcity of food in such places, or that there is something in the air that they do not like, the fact is, that they never in this country, to my knowledge, or that I can find out, have penetrated the wooded region. At Ft. à la Corne, Prince Albert Mission, Turtle Lake, Lac la Biche, Lac la Nun and Lac Ste. Anne, they have never been seen; and these places are all on the verge of the great forest, or just within its southern limit."

The immunity of the Peace River plains from the locust plague, constitutes a point of great importance in their favour, and may eventually render them, area for area, of considerably greater value than those of some parts of the Saskatchewan—a circumstance to be taken into consideration in planning a railway route.

In the following paragraphs, is given a brief digest of the more important facts bearing on the swarms of 1876 in the North-west, obtained in answer to circulars and by correspondence With the exception of the few notes placed last, the information from Manitoba is purely negative.

Mr. C. Mair has favoured me with the following note:—"In going to the Saskatchewan, last summer, I met the first hordes about the 26th of July, on the ground this side of the Little Saskatchewan. They were generally facing eastward, and seemed ready for flight. A few days afterwards, we met great flights of the insects, the air appearing to glisten with their motion. I felt no doubt whatever that their destination was Manitoba; but, as it afterwards appeared, they sheered off southwards before entering the Province, and did great damage in the States and Territories adjoining our boundary. From all I can learn at Carleton, etc., no eggs have been laid in our territory along the North Saskatchewan, and unless they come from the south, we shall be free from them this year."

Mr. A. L. Russell, of the Special Survey, sends the following notes: On June 19th, saw a few hoppers just out of the egg, a little west of Winnipeg. On July 16th, they were drifting past Fort Ellice, in clouds, to the south-eastward. At a place about forty miles north-west of Ellice, they were very numerous on August 4th, 5th, and 11th, flying north-westward on the 4th, south-eastward on the 5th and 11th. In this region of country they were to be seen almost daily from July 6th to August 10th. About a third of them were infected with parasites.

Mr. W. F. King writes, with regard to Battleford, that this place has been known to white men only since 1874, and that grasshoppers have not been seen there since. Like Prince Albert, it is protected by a belt of timber. July 29th, passed through a tract of a mile or so in width of unwinged grasshoppers, near Stony Creek (ten miles east of Little Saskatchewan River). None on the Little Saskatchewan, and only a few on the way thence to Fort Ellice. Very plentiful at Ellice in July, particularly about the 20th. Went away about the 25th. No grasshoppers seen on the way from Ellice to Battleford in August, though abundant in this region of country during July. Very abundant towards the foot of the Rocky Mountains and in the whole upper part of

the South Saskatchewan Valley, where they are said to have eaten up all the grass, driving the buffalo eastward to the vicinity of the Touchwood Hills, Souris Valley, etc.

Fort Calgarry, Bow River, N. W. T. (John Bunn.) Did not appear here during the summer of 1876, but were reported as abundant on the plains to the eastward.

Fort Walsh, N. W. T. (J. M. Walsh.) Produced from the egg, hatching about the middle of May, and remaining till the middle of August, when they flew north-westward. Other swarms arrived on the wing from Montana, about the middle of July, and for some time thereafter. These also passed on to the north-west. All crops destroyed. No eggs left.

Fort Pitt, N. W. T. (W. McKay.) There were no grasshoppers within a distance of 300 miles west of this.

Prince Albert, N. W. T. (Bishop of Saskatchewan.) No visitation of grasshoppers.

Battleford, N. W. T. (T. Little.) Did not appear in 1876, and are never known to have reached this region.

Carleton House, N. W. T. (L. Clarke.) Grasshoppers were seen in huge swarms about 150 miles south of this, flying still southward. Did not appear here.

Swan River Barracks and *Livingston, N.W.T.* (F. Norman, J. H. Kittson, M.D. and R. Miller, M.D.) Produced from the egg, from about the 25th of May till June 1st, remaining till the 7th of August, when they departed north-eastward. (One report says they died in the country.) A few arrived from the south-west about the second of June, and alighted. Foreign swarms on the wing were observed passing overhead from the 20th to the 27th of July; but, owing to strong wind, they did not alight. These also went north-eastward, or eastward. About the 8th of August, great swarms appeared from the south-west, many alighting. These departed about the 10th of August, flying southward. All crops destroyed. No eggs deposited. For twelve years before July 1875, no grasshoppers were seen here. In 1876 the green crops were entirely destroyed before the middle of June, when the insect was no larger than the ordinary house-fly. Myriads are said by the Indians to have perished in lakes Winnipegosis and Winnipeg.

Swan Lake House, N. W. T. (D. McDonald) Not seen here in 1876; and during Mr. McDonald's experience of four years very few have visited this part of the country.

Little Saskatchewan, N. W. T. (K. McKenzie.) Second week of July a large flight observed going south one point west. Hatched in this country, and north-west of Lake Manitoba.

Manitoba House, N. W. T. (J. Cowie.) Produced from the egg about the first of June, leaving about the first of August, going south-eastward, or south-westward, according to the direction of the wind. On the first of August, foreign swarms were also observed, and these continued passing and occasionally alighting for about a week, going south-westward. Crops slightly injured. No eggs deposited.

Woodside, Man., (T. Collins.) None hatched here; but foreign swarms, more or less extensive, continued to pass over for six or eight weeks, coming from the north and north-west, and going southward. Some alighted; but it is stated that though in quantity, and remaining long enough to have destroyed the greater part of the crop, "strange to say, they did nearly no damage. They did not seem to have the same energy, nor did they eat voraciously as in former years."

Gladstone, Palestine P. O., Man., (C. P. Brown.) None hatched. Swarms observed to arrive on the wing on the 27th of July. These alighted and remained about nine days. Seen passing over for several days before, but did not alight. "They probably would not have alighted on this day, but for some misty showers or shadows of large clouds. They appeared to fall only in patches, probably the spaces covered by the shadows." Also continued to pass over for about two weeks after this date, but few came down. The insects came from north-west by north, and most of them probably went south-easterly. Loss of crops perhaps 5 or 6 per cent. No eggs deposited.

Oak Point, Lake Manitoba, Man., (J. Clarke.) Observed about the middle of July for two weeks, passing overhead at intervals, when the weather was clear and warm. Supposed to come from the western plains. General direction of flight, south-eastward. No eggs deposited. Many grasshoppers observed to fall into the lake, and in several places were afterwards washed up in windrows a foot thick along its margin.

Winnipeg, Man., (F. E. Cornish.) A few passed over in August, from north-west, going southward.

St. Boniface, Man., (Hon. M. A Girard.) None. Swarms from the west observed occasionally flying overhead, without alighting, during latter part of July and to middle of August.

Little Britain, Man., (Hon. D. Gunn.) No grasshoppers here. Ten or twelve miles west of Selkirk, however, a little colony covering about 1½ acre hatched out, and were found more than half grown in the middle of July.

Lower Fort Garry, Man.. (W. Flett.) None hatched here. A few seen passing overhead about the middle of August. They came with a south-west wind.

Crookston, Minn., (E. M. Welsh.) None hatched here. Were observed to pass overhead without alighting about the middle of July. Near the first of August some alighted, and stayed a day. Came from the north-west and north, and went south-eastward. No damage to crops. No eggs deposited.

THE MECHANICAL EFFECT OF ARCTIC ICE IN PRODUCING OCEAN CURRENTS.

By Henry Youle Hind, M.A.

The area of the North Polar Ocean where salt water ice is annually formed to a mean thickness of four feet, may be assumed equal to 4,000,000 square geographical miles.

This area is less by 521,600 square miles than that of the superficies enclosed by the 70th parallel of north latitude, which is supposed to encircle a space equal to the Arctic water area frozen each year.

In order to compensate for the land area within the 70th parallel, it is necessary to add Hudson Bay and Straits, part of Davis Strait, the South-East Greenland Sea area, the White Sea, etc., in a word, wherever salt water ice is formed within the Northern zone.

During the process of freezing, salt water ice is raised about one-tenth of its volume above the level of the sea. The ice con-

sists of three varieties: common floe ice, hummocky ice, and floe-berg ice. To form "old hummocky ice," as described by Captain Sir George Nares, a large area of sea water is required, for this kind of ice is produced by the over-riding and piling up of ordinary floes, which are then cemented together by wintry frost. Floes are piled on floes, but the areas the over-riding floes occupied are frozen again.

Floe-berg ice is from 80 to 100 feet thick. A full description of it and its vast extent will be found in the journals and proceedings of the Arctic Expedition. This floe-berg ice and the "hummocky ice" are constantly streaming down from the north. Many floes associated with icebergs, finally appear in the seas washing the coasts of Labrador and Newfoundland, which they reach *via* the Hudson Straits, the Davis Straits, and the East Greenland Currents, the last named sweeping round Cape Farewell, and all uniting to form the Labrador Current.

Subjoined is a rough estimate of the area occupied by these three varieties of ice within the limits of the 4,000,000 square miles: —

I. Floe Ice.—Appproximate area formed each year, 2,000,000 square miles. Thickness, $3\frac{1}{2}$ to $5\frac{1}{2}$ feet: mean thickness, $4\frac{1}{2}$ feet. Average elevation of this ice above the level of the sea, five inches, or one-tenth of its volume. Reduced to a uniform thickness of one foot, this area would be equivalent to 833,330 square miles.

II. "Hummocky Ice."—Estimated area, 1,000,000 square miles. Estimated average winter increase above water line, one foot.

III. Floe-berg Ice.—Estimated average area in polar waters, 500,000 square miles. Estimated average winter increase above floatation line, one foot.

RECAPITULATION.

Ice above the Surface of the Sea reduced to a Mean Thickness of One Foot.

Ordinary Floe Ice - - -	833,330 sq. miles.
Hummocky Ice - - -	1,000,000
Floe-berg Ice - - -	500,000
Total - - -	2,333,330 sq. miles.

This area, one foot thick, is equal to 382 cubic miles of ice. We arrive at nearly the same result if we assume that the mean

thickness of the ice formed during the winter within the 70th parallel of latitude is five feet. Making allowance for land within this limit as before, by including Hudson Bay, Davis Straits, East Greenland Sea, etc., the area of ice thus formed may be estimated to be equal to 4,521,600 geographical miles. One-tenth above water gives the quantity of ice mechanically raised above the level of the sea by the process of freezing, equal to 2,260,800 square miles, one foot thick : a close approximation to the first estimate.

In order to gather some knowledge of the effect likely to be produced upon Ocean currents by the uplifting of so large a body of water in the form of ice above the level of the sea, we may compare it with the Gulf Stream, bearing in mind that a part only of the waters of the Gulf Stream move north-easterly after reaching the 40th degree of longitude. A large portion is directed towards Southern Europe and the northern part of Africa, as shown on Dr. Petermann's charts.

The "Challenger" found the width, depth and rapidity of the Gulf Stream, where the expedition crossed it, to be as follows : *

Width - - -	15 nautical miles.
Depth - - -	600 feet.
Speed - - .	3 miles an hour.

This gives a volume of discharge equal to 108 cubic miles per day. Hence, according to the foregoing estimate, the quantity of water required to fill the void created by the rising of the Polar ice above the sea level, would consume the equivalent of the entire discharge of the Gulf Stream for 84 hours, or $3\frac{1}{2}$ days.

The drainage area of the Polar basin is estimated to be 4,495,000 square miles, or about the same as that of the Northern Sea area covered during the winter with ice. But practically, land drainage by rivers, *glaciers* and *glacial rivers* is reduced to a minimum during the winter season. The precipitation takes place in the form of snow, and the land drainage in the Arctic zone may be estimated as not exceeding two inches during the six winter months. As a partial set off against the land drainage, there is the evaporation which takes place from the snow falling on the Polar ice. The precipitation is small within the Polar circle, and the climate of North Greenland is dry, according to Rink, Hayes, Nares, etc.

* "Challenger" Reports, No. VII.

The snow acts by weight, except during a thaw, and in this capacity it would frequently assist the formation of ice above the surface, for when it falls on young ice and presses it to the level of the water, the snow becomes saturated like a sponge by capillary action ; it then freezes and forms a light ice, thus diminishing, if not entirely neutralizing, the effects of precipitation under such circumstances. Assuming the precipitation and drainage during the winter months to amount in the aggregate to three inches within the 70th parallel, there would still remain a volume of ice mechanically raised above the mean level of the Polar Sea, in excess of precipitation, equivalent to the entire discharge of the Gulf Stream during sixty-three consecutive hours, or two days and fifteen hours.

But the mechanical up-lifting of 382 cubic miles of ice is only part of the work of winter cold in the Polar Seas. There has to be taken into consideration the enormous quantity of heavy brines squeezed out of the entire body of ice by the process of freezing, and the effect these produce upon the salinity and specific gravity of the Polar waters, hereafter alluded to. The total bulk of the ice formed each year, estimated as before stated, is equal to 3,706 cubic miles, an equivalent to the entire discharge of the Gulf Stream for 34 consecutive days ; and from this vast mass a large percentage of salt is expressed by the freezing process.

The formation of Polar ice is by no means uniform with the same mean temperature : its daily increase diminishes as its thickness increases. During the first half of the season when fresh ice or floe ice is formed, the quantity raised above the level of the sea is considerably greater than during the second half, especially if snow be absent. The quantity of heavy brines squeezed out is also dependent upon similar conditions ; and it follows that great variation in results from both of these causes must take place during different seasons.

The currents towards the North Polar circle, to supply the void created by the rising ice, should be greater in October and November, than from December to March, and greater again from March to May,* according to the snow fall and the extent of its retarding influence on the formation of ice.

Regarding the current in Davis Straits, we find that the north

* See Koldeway on the protection afforded by snow, and the effect of its disappearance before storms in the early spring.

flowing Greenland warm current extends as far as Port Foulke, in latitude 78° 20′ N., the winter station of Dr. Hayes. Capt. Sir George Nares states that "Port Foulke is at present the best known station for winter quarters in the Arctic regions. A warm ocean current, combined with the prevailing northerly winds, acting at the narrow entrance of Smith's Sound, keeps the ice constantly breaking away during the winter, and causes an early spring and a prolific seal and walrus fishery. The moisture and warmth imparted to the atmosphere by the uncovered water, moderates the seasons to such an extent, that the land is richly vegetated, and therefore attracts to the neighbourhood, and supports life in greater abundance than other less favoured localities."

An inspection of Dr. Petermann's chart of the Gulf Stream for July, enables one to see at a glance where the warm waters rise to the surface in the Spitzbergen Seas in four different sea areas. They must approach these areas as under-currents. Where "Polynias" exist in winter does not appear to be so well ascertained.

If the data I have assumed are even approximately true, the influx of warm water towards the Arctic circle, either by Davis Straits or by the Spitzbergen Seas, is in part the result of the mechanical up-lifting, during a mean period of six months, in the form of ice above the level of the sea, of a body of water sufficient to cover an area of 23,000 square miles, one hundred feet deep, at a temperature below 28 degrees Fahrenheit.

The colder the season and the greater quantity of ice formed, the stronger must be the north flowing current into the Arctic Seas, arising from up-lifted ice and descending brines. A very cold year may exert, by this means, a counteracting influence on the next succeeding year; but the retardation which must take place in the progress of the south flowing Tidal Wave, subsequently referred to, by increase of ice in the Polar Sea, is a very important element in the enquiry, and may give rise to unexpected oscillations of local climate, wholly apart from the influence of winds.

The work of up-lifting the ice of the Polar Seas is effected during a mean of six or seven winter months, and is equivalent to a demand for two and a half times the daily capacity of the Gulf Stream to be poured into the Arctic circle during that period, or at the rate of the entire volume of the Gulf Stream in seventy days, being some years more, and some years less.

To this work must be added that of the brines expressed during the process of freezing, which increase the specific gravity of Arctic waters during the winter months, when land drainage is at a minimum.

The amount of heavy brines formed by the process of freezing must not be measured merely by the whole quantity of ice estimated to be formed annually. Salt water ice continues to express brines as the temperature diminishes, and *to form heavy brines by osmotic action* during variations in temperature below the freezing point of salt water. From this property, salt water ice may be regarded as an intermittent but a productive source of heavy brines throughout the winter. These will not only carry part of their salt, but also part of their cold downwards, either to the bottom or to a zone where their specific gravity is the same as that of the medium to which they sink. They will also gather way, as sheets, horizontally, or vertically, towards the lighter and warmer southerly lying seas, which they will ultimately displace by virtue of their density, either from increased salinity or low temperature, or both combined, and thus institute south flowing and accelerate north flowing currents.

Among the leading consequences which appear to flow from the mechanical effect of ice within the Arctic and Antarctic circles, the following may be outlined:

1. A series of cold winters, by increasing the thickness of ice in the Polar Seas, will retard the progress of the Tidal Wave towards Smith's Sound, through Robeson Channel, and move the place of meeting of the tides, which now occurs near Cape Frazer, further up Kennedy Channel, and ultimately, *ceteris paribus*, into the Palœocrystic Sea itself. By parity of reasoning, a similar argument applies to Behring Straits and the channels towards Polar areas in the Spitzbergen Seas.

2. The quantity of ice coming down Kennedy Channel will diminish with the northerly movement of the place of junction of the Tidal Waves.

3. The warm currents from the south will advance further to the north up Smith Sound and elsewhere, ameliorating the climate of North-west Greenland, etc.; but an increased quantity of ice will be poured into Baffin Bay and Davis Strait, through the different sounds and straits to the west, and also from East Greenland round Cape Farewell, thus increasing the strength of the Labrador current and the severity of the climates of the shores it washes.

4. The advancing warm current, apart from the effect of winds,* will ultimately check the formation of ice, and a retrograde movement will begin, if new channels have not been opened. The place of meeting of the tides will move southerly, and the oscillation described may continue for centuries. If, however, a new channel should be formed for the efflux of ice in the Spitzbergen Seas or the west side of Baffin Bay, very considerable local changes in climate would result.

5. If, owing to a gradual up-rising or depression of the land area within the Polar circle, an increased or diminished quantity of Polar ice should be produced, the mechanical effect would be strongly felt in opposite directions, according to the character of the oscillation. These supposed conditions may have thus greatly influenced Arctic climate during past geological ages. Similar reasoning applies to the Antarctic circle and the mechanical influence of Antarctic ice.

If, for instance, an up-rising of the land, or its equivalent, a lowering of the ocean level took place, one effect would be that in the course of time the Polar Sea would become brackish and ultimately fresh or glacial, more salt would be expressed by freezing, and conveyed away by cold currents, than could be introduced by the inflowing compensating currents through diminished channels of ingress, which would gradually assume the form of outward flowing river beds. The tidal wave would be impeded, Northern Europe would become colder, and North America warmer.

On the other hand, a sinking of the land would greatly facilitate the southerly progress of the Tidal Wave from the north, move the place of junction farther to the south, and gradually clear the Polar Sea of ice, thus greatly ameliorating its climate. Northern Europe would become warmer, and North America colder.

According to this view, the existing evidence of rising land in the Arctic regions, points to a gradual increase of Arctic cold in Northern Europe.

6. The north flowing warm currents should be greater in the winter than towards the close of summer, and they probably assume the form of intermediate moving sheets or stripes of water, similar to the horizontal cold sheets and vertical cold

* See Report by Capt. Sir George Nares, on the effect of an "Open Season" and of Winds.—Arctic Journal, page 36.

stripes of water in the body of the Gulf Stream. That this arrangement exists in the Labrador current is rendered probable from the habits of innumerable, indigenous and non-migratory schools of fish, which winter, not only in the ice-encumbered seas on the Atlantic coast of Newfoundland, but also throughout the sea area confronting the coast of Labrador, where the sea not unfrequently freezes in one unbroken sheet, ten to thirty miles out from the nearest land. This arrangement would also be in accordance with the temperature of zones observed by Scoresby in the Arctic Sea, in the Gulf of St. Lawrence by Dr. Kelly, and in the Baltic Sea by Professor F. L. Ekman, thus comprehending closed as well as open seas.

ON THE OCCURRENCE OF APATITE IN NORWAY.

By Messrs. W. C. Brogger and H. H. Rensch.

[Translated and abridged from the "Zeitschrift der Deutschen Geologischen Gesellschaft"; Vol. 27, Part 3.]

The Norwegian deposits of apatite, some of which had for years yielded a large quantity, had been but little studied up to the year 1874. This account is the result of a six-weeks' journey during July and August, 1876, made at the expense of the government, in order to study in detail some of the most important deposits.

Apatite in Norway has up to the present time been found especially in veins in the primary range of the southern coast between Langesundsfjor and the town of Arendal, and also at a few points to the north of the old mining town of Kongsberg in the district of Snarum.

In proceeding to the description of the several deposits (more than twenty in all) visited by us, let us observe that we shall arrange them according to the nature of their respective rocks. In this way the remarkable connection that undoubtedly exists in our opinion, between the gabbro and the Norwegian deposits of apatite, will be at once evident to the reader.

We will first describe the veins intersecting the gabbro; and then those traversing the crystalline schistose rocks of the primary range and partially the granite, commencing with those that occur in the immediate neighbourhood of the gabbro.

1.—Deposits in the Gabbro.

Oedegarden (Bamle District).

This deposit, which is the richest at present worked, was discovered in March, 1872. Its richness caused great speculations, whereby the price of many deposits already known was raised enormously, and in the districts wherein apatite occurs a genuine apatite-fever was developed among the inhabitants. Up to the date of our visit (in July 1874) it had already yielded, according to the exact figures of the proprietor, over 3,200 tons (of 2,000 lbs.) of the approximate value of $112,500. The apatite has been shipped chiefly to England and Germany, and recently to France and Sweden also. It is sold for £6 5 0 to £6 6 0 stg. per ton.

The veins of Oedegarden lie at the foot of a low rocky ridge running N. E. and S. W., which forms one side of a small valley, whose centre is occupied by a little bog. The ridge consists of hornblende rocks in highly inclined, not very distinct, strata, chiefly hornblendic gneiss (the plagioclase white with twin-striping) which is in part very poor in quartz. Sometimes the quartz disappears entirely, and the rock becomes the diorite-slate of the German lithologists. On the other side of the bog the same rocks occur, alternating with ordinary gneiss and quartzite. At the foot of the ridge there occurs a small zone of a light rock, without a trace of cleavage or stratification. This rock is a peculiar variety of gabbro, which we shall name "spotted gabbro." This medium—to finely—granular rock consists, in varying proportions, of brown lustrous hornblende (distinctly cleavable parallel to the planes of the hornblende-prism) and white to greyish-white labradorite. In the "spotted gabbro" the latter mineral is without cleavage planes, compact or granular, with a splintery fracture, lustre vitreous to slightly fatty, and in splinters translucent. Its aspect recalls at the first glance quartz or moist snow. Before the blowpipe it fuses somewhat more readily than ordinary labradorite to a water-clear or milk-white glass. Hardness, 6, sometimes a little less. An analysis made by S. Wlengell exhibits the ordinary composition of labradorite: SiO_2 54.00, Al_2O_3 (and a trace of Fe_2O_3) 24.13, CaO 7.89, MgO 0.95; loss by heating, 1.22 per cent. The alkali was not determined.

The specific gravity of the "spotted gabbro" varies somewhat on account of its varying composition. A clear-coloured, cleavable

variety, the one that was analysed, is 2.78. A darker, finely-granular variety is 2.89 (the sp. gr. of the common dark violet gabbro of Hiasen is 3.08). The peculiar relationship which exists between the "spotted gabbro" and the apatite bearing veins in several deposits will be more closely discussed further on.

The ordinary dark violet gabbro, moreover, also occurs at four points near Oedegarden.

The small zone of "spotted gabbro" is intersected by two coarsely granular veins of granite, which, judging by its appearance, belong to the older granites that are never otherwise met with outside of the primary hills. This circumstance indicates that the gabbro here must be older than the gabbro masses that intersect the Sparagmite and Silurian formations in other parts of our country.

The rich veins characteristic of this locality occur in the "spotted gabbro"—not at all in the strata of the primary hills, or in the granite or in the small portions of common dark gabbro. They can be briefly designated as *apatite-bearing mica-veins*. A brown magnesia-mica is in many veins almost the only mineral, generally accompanied by green enstatite along with small lumps of apatite. As the quantity of mica decreases and that of apatite increases, the character of the veins changes. The richer veins are distinguished by the fact that the mica almost exclusively occupies the sides, and apatite the centre. In regard to the relative position of the veins a certain regularity is observed, as they almost all dip slightly towards the ridge, viz., towards S. S. W., S. and S. E.

The veins are very numerous, and, moreover, so often branched and connected by cross-veinlets, that the entire deposit resembles a net of veins covering a stretch of 1600 meters.

After these brief preliminary remarks, we bring the reader to the largest and most interesting veins.

The first vein to be described is a mass of mica about twelve feet wide, chiefly in fine scales which contains crystals of a greyish-green hydrous enstatite and lumps of apatite several feet in diameter. Some of its finer veinlets consist of raven-black hornblende, instead of mica. The country rock—the "spotted gabbro"—is here coarsely schistose, and contains very small grains of rutile, arranged parallel to the other minerals. The cleavage, which is not parallel to the strike of the vein, becomes in the case of one of the stringers gradually more indistinct, until the

rock passes into a finely granular, almost compact, greenish rock. The portion of country-rock enclosed by the net-work of veins is partly a peculiar variety of the "spotted gabbro," which on account of its appearance has received from the miners there the appropriate name of "sandrock." Its peculiarity is that the labradorite crumbles between the fingers into very small grains like the grains of a friable sandstone; and it often contains small scales of a brown mica, instead of hornblende or diallage. Its sp. gr. is 2.79. Farther eastward this sandrock borders the mica mass.

Several mica veins, the largest being quite 25 feet thick, were come upon farther eastward by digging through the clay that overlies the foot of the ridge. Still farther eastward a long prospecting trench cut through the soil in a N. W. and S. E. direction exposed not fewer than twelve veins. They all dipped slightly towards the ridge and were tolerably parallel to one another, the largest being six feet thick. Only one of these veins seemed to contain much apatite; the others consisted of phlogopite enclosing some lumps of apatite and hydrous enstatite.

The second important vein to be described is very rich in apatite. It dips slightly (about 30°) towards S. E.; and its outcrop was traced by exposures for about 160 feet. The banded arrangement of the minerals forming the vein, which is usual in the richer veins of this deposit, is very marked here; the sides being lined with a slight belt of brown phlogopite, while the centre is almost exclusively filled with apatite. In the vein the thickness of pure apatite was 7—8 feet; this being the greatest yet observed at Oedegarden. The cross-stringers here exhibit the only instance known to us in this deposit where the apatite comes directly in contact with the country rock.

The third vein is a six-foot mass of mica-bearing apatite, which is forked and shattered towards the east, and has been traced for about 70 feet.

No. 4 resembles No. 2.

No. 5. One larger and several smaller veins, striking in different directions, are here close together. As usual, the centres of the veins consist of apatite, separated from the country rock by brown phlogopite. They are enclosed on both sides by a zone of the above-mentioned "sandrock," whose limits are somewhat sharply defined against the ordinary "spotted gabbro."

In this neighbourhood there occurs a small 8-inch vein, which

is distinguished by its minerals from the ordinary veins of Oedegarden, in as much as only its western part consists, as usual, of phlogopite and apatite, whereas in the eastern portion the phlogopite is replaced by hornblende. In contact with the country rock the hornblende is finely granular, but becomes coarsely crystalline towards the centre of the vein which is occupied by apatite.

Hornblende occurs also in several other veins of Oedegarden, sometimes replacing the phlogopite, and at other times accompanying it; in the stringers raven-black and finely-granular, but brown and coarsely crystalline in the veins.

No. 6, which gave the best specimens of hydrous enstatite, and No. 7 are both slightly-dipping veins of phlogopite, apatite and enstatite, arranged in bands, as usual.

In contact with the country rock the phlogopite is always in fine scales and often speckled with small grains of apatite. The individual scales are usually grouped without system; but sometimes there can be observed traces of a parallel structure, whose direction lies at an angle with the edges of the veins. Towards the middle of the veins the phlogopite becomes always more coarsely crystalline: we have seen plates at least half a foot square. These are often crumpled, twisted and broken, and sometimes are surrounded by apatite.

No. 8 is an ordinary mica-vein, bearing apatite, and is visible on the surface for a stretch of 60 feet. Where the vein wedges out in its continuation towards the west there occurs a zone of "sandrock" 86 feet long representing the vein, which still continues underground—as has been proved by pits.

No. 9 has yielded the greatest quantity of apatite of all the veins of Oedegarden up to the present time. It has been traced 300 feet in length, and 120 feet in depth; its dip is 25° at the surface, but lower down is 30°. Above ground the vein has altogether disappeared for a length of more than 60 feet, whilst underground the connection has been proved. Of all the veins this is the most regular; for the apatite, which occupies the middle of the vein, and is separated from the country rock by a usually thin zone of phlogopite and hydrous enstatite, has occurred partially in bunches, but generally in sheets. The thickness of the vein has varied a good deal.

A profile of the strike of this vein would closely resemble those of the other veins of Oedegarden.

For a short stretch between this and the following vein the "spotted gabbro" is replaced by a compact white labradorite, containing innumerable red specks of rutile.

No. 10 exhibits very interesting relations. The vein-mass, which consists of phlogopite with crystals of hydrous enstatite scattered here and there, encloses, in its upper portion, large bean-shaped lumps of dark apple-green and brown kjerulfine. Deeper down large lumps of the country-rock (partially "sandstone") and of apatite are enclosed by the vein-mass. Still deeper the vein has much the same character, although sometimes compact apatite occupies its centre.

Besides the minerals already mentioned, we observed in the veins of Oedegarden rutile rarely, sometimes in crystals. And on the dump of vein No. 2 we found rutile and brown titanite with green kjerulfine.

Calcspar, quartz, pyrites and copper pyrites were found in stringers, and tourmaline and albite in a geode (vein No. 1).

Finally there occurred in the clay that overlaid the foot of the ridge, as a secondary formation, specks of a blue mineral consisting chiefly of iron and phosphoric acid, apparently vivianite.

Oedegardskjern.

The bold N. W. Shore of the small lake that lies a little to the S. E. of the deposit just described consists of a kind of rock closely resembling the "spotted gabbro" of Oedegarden.

Here there have been principally mined three large vertical veins, which can partially be characterised as "apatite-bearing veins of enstatite." The most westerly of them is a vertical vein, up to six feet in thickness, of granular green enstatite, locally intersected by stringers of an almost compact bluish-black variety. Towards the lake the vein carries on its western side much apatite, which farther on separates from the large vein-mass as a distinct vein, along with some green bronzite and rutile; both veins are intersected by stringers of quartz. Close to the large vein there are several stringers, consisting partly of apatite-bearing hornblende and partly of a mixture of rutile with some hornblende and calcspar.

Farther eastward there occurs a vertical vein striking N. N. W., which has yielded about 60 tons of apatite. It consists at the sides of hornblende, and in the middle of apatite and some rutile. Small bits of the country-rock were enclosed in the apatite.

Still farther eastwards there occurs a third vertical vein of granular green and compact bluish-black hydrous enstatite, sometimes crystallised towards the middle of the vein, which part is occupied by apatite and rutile. In the neighbourhood there are smaller veins of red feldspar and rutile along with some of compact red feldspar, rutile, hornblende, apatite and the same green enstatite that occurs at Oedegarden and in many other deposits.

Fogne (Gjerrestad District).

This deposit has been already described by Joh. Dahll. The country rock is a "spotted gabbro" similar to that of Oedegarden, but often of coarser grain and more schistose. One vein consists chiefly of magnetic pyrites and pyrites with some apatite (often crystallised); another large vein consists of rutile and green pyroxene (both sometimes crystallised) along with apatite.

Hiasen (Gjerrestad District).

Hiasen is a small cone of gabbro that rears itself above the surrounding strata of the primary hills. The deposit can be briefly described as apatite-bearing veins of hornblende; which were very profitably worked in the years 1858-1859.

Asildsdal (Hiasen). The rock in which the veins occur is a hardly recognisable gabbro. The veins are large, but irregularly branched and split up. They consist of ordinary coarsely radiated hornblende, which carries apatite in lumps. On the dumps we also found ilmenite, spathic iron, feldspar, quartz, scapolite, tourmaline and calcspar. In one of the pits the vein of hornblende changed into a mass of calcspar.

Persdal (Hiasen). The veins are irregularly bifurcated, and sometimes more than five feet thick; they consist of coarsely radiated hornblende, sometimes with lumps of apatite, and sometimes without it. The country rock is a "spotted gabbro." Some of these veins also contain magnetic pyrites, which sometimes forms the chief mineral. (*Note.*—An illustration of these latter veins is inserted here.) On the right, one sees the coarsely radiated hornblende, whose individuals are arranged at right angles to the edge of the country rock; moreover, the vein mass consists chiefly of magnetic pyrites, wherein numerous dirty yellowish-green crystals of apatite lie, whose corners and edges have been rounded and apparently fused. On the right hand of the drawing, isolated fragments of hornblende are also observed

in the magnetic pyrites. Another small adjacent vein consists exclusively of coarsely crystalline prisms of hornblende, arranged perpendicularly to the side-walls.

The above-mentioned fact, that the crystals of apatite enclosed in the magnetic pyrites have been rounded on the corners and edges, has been met with by us also in other localities where magnetic pyrites is the principal mineral of the apatite-bearing veins. On Hiasen we saw for the first time, on a small scale, an interesting circumstance, which we shall mention more minutely farther on, in describing the following deposit. In the common dark gabbro, namely, there occurred, close to the veins, some very small stringers of hornblende (not over half an inch thick) carrying apatite, enclosed on both sides by a zone, up to three inches thick, of a "spotted gabbro"—similar to that of Oedegarden. As already mentioned, the veins of Hiasen that are described above occur in a "spotted gabbro," which encloses it on both sides; whereas the rock of Hiasen is otherwise a common dark gabbro. The "spotted gabbro" does not extend to equal distances on both sides of the veins; whilst in one direction it stretches far towards the peak, it is necessary to go only a few steps in the other in order to encounter the common dark gabbro.

Regardsheien and Ravneberg (Soendeloer District).

Regardsheien and Ravneberg are two portions of one and the same ridge of rock, on whose precipitous declivity towards the Soendeloevsfjord, the veins of apatite crop out, which (next to those of Oedegarden) are at present most full of promise. The ridge consists chiefly of gabbro, which intersects the strata of the primary range; and the veins occur in the gabbro. Even in sailing past, their position can be made out from the vessel, as sometimes the piled-up dump beneath marks their locality, and sometimes the rich veins themselves show as a clear stripe upon the dark rock.

On Regardsheien there are five large veins, 150 to 200 feet long, and $\frac{1}{2}$ to $1\frac{1}{2}$ feet thick. The veins, which pinch out, as usual, are approximately parallel, overlying one another at a small angle; four dipping slightly (30°), but the fifth more strongly, inwards towards the ridge. In their course, they send numerous small off-shoots into the country rock. The veins consist of apatite-bearing hornblende, the sides being coarsely-radiated hornblende

and the middle apatite, whose greatest width is one foot. The hornblende is often full of brown scales of mica, which occurs also in larger quantity. Sometimes the entire width of the vein is occupied alone by apatite or alone by hornblende.

On Ravneberg occur three groups of veins. The vertical *gangstock* of the central group, whose veins are all connected with one another, consists of a coarsely crystalline hornblende and mica ; both being mixed with lumps of apatite and green enstatite like that from Oedegarden. The other veins of this group are regular and continuous, rarely one foot thick ; one dips slightly towards the ridge, the others are vertical. They consist almost exclusively of reddish or greenish apatite, on both sides usually separated by a thin crust of green enstatite from the country-rock. The green enstatite was also found in larger crystals, sometimes surrounded by apatite, but usually jutting out from the *saalband* towards it. Quartz was also sparingly observed.

On the cape jutting into the Soendeloevsfjord there is a group of very pure veins of apatite ; only on its *saalbander* do hornblende, mica and enstatite occur. The apatite is usually of clear colour, white or greenish, but brick-red where in contact with the crystals of hornblende (possibly caused by its iron-compounds ?).

At a greater elevation there occurs yet a third group of veins, very similar to the preceding ones. The declivity is so precipitous that the quarries can be reached only by ladders.

What we observed on a small scale at Hiasen is displayed at Regardsheien in larger and bolder characters. The principal rock of this deposit is, as already mentioned, a common dark gabbro (with violet twin-striped labradorite). But in the immediate neighbourhood of the veins we do not meet with this dark gabbro, but with the above-mentioned "spotted gabbro." This rock surrounds on both sides, as a zone of varying width, not only the larger veins, but also their smallest stringers and bifurcations, always exactly following their contour. But this constant relation is accompanied by certain irregularities. Sometimes the zone is broader on one side of the vein than on the other. In the case of one of the largest veins, which sends out so many off-shoots as to form an enclosing network, wherever this is very dense, the following observation may be made : the "spotted gabbro," which usually surrounds every branch and

off-shoot with an especial zone, forms here a general larger zone around the entire net, wherein the dark gabbro between the off-shoots entirely disappears. The smaller veins of Ravneberg behaved similarly to those of Regardsheien. The zone of "spotted gabbro" is here usually about six inches thick on each side, while that of the large *gangstock* is much thicker. We observed here that small stringers of hornblende (some of them barren of apatite), hardly one cm. thick, were surrounded by as broad a zone of "spotted gabbro" as the larger veins. Each of the two other groups of veins of Ravneberg was surrounded by a large portion of "spotted gabbro."

The manner and method of the occurrence of "spotted gabbro" in the deposits just described throws more light on the Oedegarden deposit.

We have studied this rock in close contact with the apatite-bearing veins. On Oedegarden it is no longer every single vein that is surrounded by an especial zone of "spotted gabbro." The entire Oedegarden vein-system, with its numerous and large veins, occurs in a small band of this gabbro. Only at a couple of points could we discover the dark violet gabbro, which is elsewhere so common in this region. The boundary between these two varieties of gabbro is always tolerably sharp: on Regardsheien we broke out hand specimens of medium size, one-half of which consisted of the ordinary dark gabbro, and the other of the spotted variety, while the centre was a transition stage between the two. In regard to the relation between the "spotted gabbro" and the other neighbouring rocks, we observed on Oedegarden that the labradorite sometimes, although very rarely, showed cleavage planes with twin-striping. In this case the rock can only with difficulty be distinguished from the adjacent quartz-free (oligoclase) hornblendic gneiss, all the more so because the schistose texture of the latter is easily recognisable only at some distance from the boundary of the gabbro. We ourselves therefore at first took the "spotted gabbro" of Oedegarden for a portion of the gneiss altered by contact with the veins—which it certainly cannot be.

Besides the above-described deposits there are some others known to occur in the gabbro; but we had no opportunity to examine them.

II. Deposits that do Not Occur in the Gabbr

As already mentioned, we shall describe first those that the immediate neighbourhood of the gabbro.

Krageroe.

This deposit of apatite, formerly the richest in Norwa been already briefly described by Joh. Dahll. As a d description of the apatite veins of Krageroe, the fruit of years' research, is expected from our distinguished ge Tellef Dahll, we shall call attention only to those detail seem to be of value for the comprehension of the other de Mr. Tellef Dahll was our experienced guide.

The Krageroe deposits may be generally described as se tions of hornblende, containing apatite. They yielded years 1854-58 about 5,200 tons of apatite, of the value of $112,500 ; for the price of apatite was then lower than There were three large segregations, lying at the base of a The peak of the cone consists of gabbro, which is only paces removed from all the veins.

In the Vuggens mine a vein seven feet thick, with a sligl here penetrates partly the granite and partly the strata primary rocks. Both sides of the vein consist of a finely granular hornblende, containing small lumps of a The middle of the vein is occupied by coarsely radiated blende enclosing lumps of apatite up to two feet in dia which sometimes have a plainly hexagonal section. C boundary between the finely granular and the coarsely ra hornblende there sometimes occurs, especially in the foo rutile along with a greenish-grey steatite and an impe fibrous mineral resembling asbestos. The two latter are som combined together into large radiated masses, projecting t the middle of the vein, and having a contorted internal stru In their combination large crystals of hornblende occur, principal axis lies in the same direction as the fibres asbestos-steatite. In the coarsely radiated hornblende middle of the vein there occur irregular geodes, into the ends of the hornblende crystals project, generally coat quartz and calcspar ; the latter being the younger deposit. hornblende crystals are sometimes broken and cemented with quartz.

The two other segregations of Krageroe showed similar conditions. The lumps of apatite sometimes reached an enormous size. Besides the minerals already mentioned, ilmenite (in crystals celebrated because of size), titanite, albite, calcspar and apparently several other minerals were found when the mines were worked.

Oedegarden (Bamle District).

S. E. from the largest of the Oedegarden veins and on the other side of the ridge at whose foot lie the apatite veins previously described, there occurs on the declivity towards Havredal an irregular vein of hornblende ½ to 4 feet thick, which has been traced for about 100 feet, intersecting the vertical strata of a hornblendic gneiss poor in quartz. The vein consists of hornblende and a mineral resembling hornblende along with some quartz, brown mica and lastly apatite and rutile in lumps. The apatite is red and similar to that of Krageroe; of whose hornblende veins this whole deposit reminds us.

In the Jungfernschurf, near to Oedegarden, there occurs in the crystalline slates a small portion of a coarsely granular granite, poor in mica, which is intersected by a diabase vein perfectly similar to the numerous veins of the Christiania valley. A vertical vein, one foot thick, of grey and flesh-red apatite along with some hornblende and green enstatite intersects the granite as well as the slates. Several similar stringers occur in the granite, wherein stringers of green enstatite abound.

Near Roenholt, a little to the north of the Oedegardskjern veins, described on page 429, there is a very interesting occurrence. A coarsely granular granite intersects the highly inclined strata of hornblende slates (strike being about N. E. and S. W.). Both granite and slates are interwoven by veins, consisting chiefly of a green pyroxene,* rich in magnesia—in part a very fine malacolite—of rutile, brown coarsely crystalline hornblende † and, finally, apatite. The pyroxene, rutile and apatite occurred sometimes in large crystals. The rutile crystals were sometimes bent and twisted. The thickness of one of the veins, around which the slates were folded, was four feet. The veins send numerous off-shoots into the granite, and sometimes even enclose fragments of it, whereby the relations are very much complicated.

* The angles of the two cleavage planes were 87° 23′ and 92° 39′.

† The angle of the very lustrous cleavage planes was 124° 24′.

(*Note.*—A number of other deposits are then briefly described. But the authors remark that they are of no practical importance and were not critically studied; therefore it is not thought necessary to translate these descriptions.)

Our apatite deposits have all been formed in the same way. The veins show in regard to their mineral contents conditions differing from one another; we will, therefore, attempt to point out, especially on this point, connections and transitions.

There occur at Oedegarden almost pure veins of mica, apatite-bearing veins of mica, mica-hornblende veins and veins of hornblende, all under precisely similar conditions; in many small deposits of hornblende and also in the great segregations of hornblende at Krageroe hornblende, and not mica, is the chief mineral. The veins of Ravneberg, which remind one very much of those of Oedegarden, form with their vertical mica-hornblende segregation a perfect transition to the segregations of Krageroe.

The apatite-bearing veins of hornblende often carry magnetic pyrites: transitions from the one to the other may be observed, as it gradually increases in quantity. At Bamle we saw small veins consisting exclusively of magnetic pyrites, in one and the same deposit also the magnetic pyrites occurs at one time merely as an accessory, at another as almost the only mineral.

In the apatite-bearing veins of hornblende feldspar or quartz, or both together, occur not unfrequently. Here also through several deposits it can be traced out how the feldspar or quartz increases in quantity until it predominates; which justifies the designations "apatite-bearing feldspar veins," or "quartz veins." When both minerals predominate and mica is also present we have the so-called "apatite-bearing granite veins," which are hardly to be distinguished, except by the apatite, from the numerous ordinary granitic veins of the region.

Scapolite occurs sometimes as merely accessory, at others as a more important element, and in one deposit as almost the only mineral. The oft-mentioned crystals of green enstatite recur in their characteristic shape and with the same chemical composition in the various deposits, and connect them together. Enstatite also sometimes occurs with the apatite as almost the only mineral, so that the deposits merit the name of "apatite-bearing enstatite veins."

An equally common and characteristic mineral is rutile. This also in rare cases predominates.

When one considers how very greatly the mineral contents and the external aspect generally of apatite-bearing veins vary, neither the deposits of Asildsdal with their masses of calcspar, nor those of Oxoiekollen with their predominating albite, can offer sufficient grounds for distinguishing these deposits from the other apatite-bearing deposits. For calcspar and apatite are also found in several other deposits; and in other respects Asildsdal and Oxoiekollen are not abnormal.

Also the circumstance that in several deposits one and the same vein sometimes exhibits in its various parts an entirely different mineral composition, can only be another ground for regarding the veins as identical formations. The above instances have proved that all grades of transition occur between those deposits where apatite occurs only sparsely and as an accessory, and others where it forms the chief mineral. This is shown also in one and the same deposit.

Also in other respects, viz. in the arrangement of the minerals, in the shape of the veins, etc., could a similar transition series be produced as proof of the identical nature of the veins.

Our apatite deposits are veins. The occurrence of apatite in beds, sometimes forming small strata in the sedimentary rocks, has been described in several countries. In Sweden apatite has been described as a noxious admixture with the iron ores of the Graengesberg, which are said to be "beds" in gneiss. The apatite occurs in our veins in an entirely different manner.

Our apatite-bearing veins occur without difference in the eruptive, as well as in the stratified rocks of our primary range. In the latter case they are perfectly independent of the strike and dip of the strata, with one exception, viz., the kjerulfine deposit at Havredal; which, however, as it agrees in all particulars with the apatite-bearing veins, cannot be separated from them. The veins traverse gabbro, granite, hornblende slates and hornblende gneiss, mica schists and quartzite. This fact that perfectly identical veins occur in different rocks (e. g. the characteristic veins of hornblende with apatite and magnetic pyrites occur at Hiasen, etc., in gabbro, and at Hougen, etc., in hornblende slates), seems to us completely to contradict the idea of the veins being formed by separating out from the country-rock (in which way Scheerer has explained the formation of our coarsely crystalline veins of granite). These granite veins, like many of our apatite-bearing veins, show sometimes a sym-

metrically banded arrangement of their ingredients ; the feldspar occupying the sides and jutting out in coarse crystals towards the middle, which is filled with quartz.

Dr. T. Sterry Hunt has assigned* quite a different mode of formation to the apatite-bearing veins of Canada, which, according to the description, must be perfectly similar to ours. He distinguishes three different varieties of veins as occurring in the Laurentian formation: 1. Lead-bearing veins, which are said to be much younger than the other two varieties; 2. Granitic veins, which would seem to be comparable to our ordinary coarsely crystalline granitic veins, as Dr. T. S. Hunt has himself pointed out; 3. Calcareous veins, which are generally associated in their occurrence with the eozoon limestones, which Dr. Hunt considers to be sedimentary. This third group of veins, which is common in Canada, and also sometimes occurs in the northern part of the United States, is usually rich in calcspar, and corresponds to our apatite-bearing veins. The similarity is surprising.

Dr. T. Sterry Hunt tries to explain the formation of the calcareous veins, as well as the granitic veins already mentioned, by hot solutions charged with the ingredients of the stratified rocks having deposited the dissolved matters in vein fissures; he terms veins formed in this way "endogenous." He seeks to establish his theory especially upon the fact that almost all the vein-minerals occur also in the stratified country-rock, as well as by the fact that calcareous veins occur especially in the limestone and the granitic veins, especially in the gneiss and micaceous schists. These conditions are not met with in our veins. We are not aware of apatite or any other mineral containing phosphoric acid having been found in the country rock of the veins. This holds good not only of the phosphatic minerals, but also of rutile and many other minerals occurring in the apatite-bearing veins. And in no other respect, although our attention was especially turned to this point, could we observe any definite relation between the minerals of the veins and those of the country-rock. In a rock of such constant composition as gabbro there occur large, almost pure veins of enstatite, veins of mica, segregations of hornblende and mica, veins of apatite, etc. The apatite-bearing veins and the numerous granitic veins occur also side by side in the same rocks. On the other hand, it could be

* Geology of Canada, 1866, pp. 186–233.

proved that veins of similar mineralogical composition may occur in entirely different sorts of rocks (*vide supra*).*

Our apatite-bearing veins are of eruptive origin.. We shall first discuss a point which would seem to oppose their eruptive origin. In many deposits, some of them being the principal ones, there occurs, as already mentioned, a symmetrical arrangement of the vein-minerals. Thus, for instance, in the Oedegarden veins brown phlogopite and sometimes also crystals of green enstatite, in many hornblende-deposits hornblende, and in several apatite-bearing enstatite veins enstatite occupies the sides of the veins, while their centre consists of apatite and very often also of other minerals. This banded arrangement might seem perhaps to indicate a regular gradual deposition of the minerals out of watery solutions. Frequent exceptions, however, occur even in the most regular deposits; wherein no such systematic arrangement is observed. Sometimes, the vein minerals throughout the entire extent of the veins are mixed with one another equally and without arrangement, at other times the veins do not contain the same minerals in their different portions. In veins that consist chiefly of a single mineral, apatite and other minerals are often distributed equally through the entire vein mass. The symmetrical structure of our veins can, with regard to regularity, be in no way compared to that which is so splendidly displayed in many metallic veins.

We explain the banded arrangement of the minerals in our apatite veins by the assumption that under favourable conditions the minerals that now occur on the sides of the veins (usually hornblende or mica) were first crystallised out of the magma under pressure.

The veins exhibit also the phenomenon so often observed in eruptive veins, that the vein-minerals are fine-grained on the walls next the country-rock, while in the centre of the veins they have formed larger crystals.

In the Oedegarden veins, moreover, the fine scales of mica near the walls are sprinkled with small grains of apatite. Both minerals must therefore have crystallised out together, before the large crystals of mica that project into the apatite, and finally the central apatite itself was formed out of the still liquid vein

* Limestone occurs very seldom as a rock, so far as we know, in the entire region where the apatite-bearing veins occur.

stone. A vein at Krageroe exhibits still more distinctly a similar sequence of crystallisation of the minerals in the hornblende veins. The side portions consist of a mixture of finely granular hornblende with grains of apatite ; from this rather sharply defined zone the large crystals described above project into the central vein-mass. We explain this arrangement in the following way, viz., that the zone of the finely granular mixture crystallised while the vein-mass was still in motion : on the cessation of its upheaval, there first solidified, along with apatite, the above-mentioned large crystals and the coarsely radiating hornblende that occurs in their continuation, along with rutile, and, finally, the rest of the coarsely radiating hornblende and the apatite associated with it.

The coarsely crystalline hornblende in the middle of this Krageroe vein exhibits another phenomenon that seems irreconcilable with a gradual deposition of the minerals from solution, viz., large spheroidally arranged crystals of hornblende radiating from a centre inside of the vein ; the formation of these may be readily explained by the assumption that the crystallisation of the liquid vein-mass took place not only on the walls of the country-rock, but also about a centre inside of the magma. We recollect, moreover, that in several of our deposits of apatite fragments of rock occurred in the vein mass and surrounded by it. Joh. Dahll states that at a considerable depth in Lykkens mine at Krageroe rock fragments occurred in such quantity that a genuine breccia was formed. But the most remarkable of these observations is the discovery of small (about two inches long), angular, sharply defined fragments of rock, which were enclosed in the apatite of our Oedegardskjern vein. These fragments consist of granular quartz and some hornblende ; the country-rock here is a gabbro somewhat similar to the "spotted" gabbro of Oedegarden. Since neither the vein nor the surrounding rocks contain quartz and the fragments are in no respect similar to the mineral aggregates that we have otherwise met with in the veins, but are similar to several of our ordinary quartzites, we can therefore scarcely doubt that they are also true fragments of rock, which cannot, on account of their character, be derived from the country-rock. We are inclined to regard them as fragments of rock that have been broken loose at a considerable depth and brought to the surface by the liquid vein-mass.

A phenomenon which also seems best explained by the assumption of the eruptive nature of the veins, is seen in the twisted and bent crystals of various minerals that frequently occur in several deposits. In the Oedegarden veins bent crystals of enstatite often occurred. Still more frequently are the large plates of mica in veins of apatite crumpled and twisted. At Roenholt bent and twisted crystals of rutile occurred embedded in the other minerals of the vein. A pair of bent and twisted crystals of apatite an inch long, which—to judge by other crystals found at the same place—must have been surrounded by a homogeneous mass of quartz, seemed very remarkable. The crystals of apatite when first formed, while the mass of quartz was still plastic, may have obtained their present contorted shape from the pressure caused by the motion of the quartz.

We must also mention the broken crystals of enstatite at Oedegarden that are cemented by apatite, and the fragments of crystals of hornblende that occur in magnetic pyrites on the *saalbaender* of many veins. Both occurrences make it probable that the entire vein mass did not simultaneously solidify. This is also indicated by the banded arrangement of the veins. It is probable that the apatite and magnetic pyrites were still a plastic mass when the minerals of the *saalbaender* had already crystallised out. And when these latter, in consequence of the motion of the vein mass, were broken they were cemented by the apatite or magnetic pyrites.

We may here recall to mind the crystals embedded in magnetic pyrites, that were rounded and even fused on the edges and corners.

As already mentioned, where the apatite-bearing veins occur in strata, they are perfectly independent of their strike and dip; showing in this respect the usual behaviour of eruptive veins.

We must mention still another point wherein these veins differ from ordinary metallic veins, viz., in the entire lack of empty spaces filled by crystals dividing them into two symmetrical halves. Even ordinary geodes are met with only as rare phenomena in the apatite-bearing veins.

Apatite has been long known as a mineral crystallisable out of a hot liquid mass. Forchhammer obtained small crystals out of a fused mixture of salt, chalk and bones; small crystals of apatite are among the commonest associates of melaphyre. Therefore it cannot be astonishing that apatite occurs in empty veins.

The apatite-bearing veins bear a certain relation to the gabbro. We must here recall to mind that the apatite-bearing veins occur in a region where gabbro frequently intersects the strata of the primary rocks. All the important deposits of apatite occur either in gabbro or in its immediate vicinity. As the gabbro has suffered far more alteration by the eruption of apatite veins than the other rocks have, perhaps the assumption is justified that the gabbro may have been not perfectly solidified when the veins burst forth.

The eruption of the apatite-bearing veins occurred either simultaneously with or immediately after the outbreak of these gabbro masses. A number of observations would seem to suggest that the vein masses when they burst out were hydrous and accompanied by solutions and gases. We mentioned that the veinlets of Regardsheien and Ravneberg were sometimes surrounded by as broad a zone of the "spotted gabbro" as the larger veins themselves; and also that in some cases this zone is broader on one side of the vein than on the other; farther, that the direction of the small off-shoots is continued by veinlets and stringers of a schistose gabbro inside of the granular "spotted" variety. Finally, we would recall to mind that in several deposits the "spotted gabbro" extends far from the veins. When these considerations are all borne in mind, it seems clear that the alteration of the gabbro is due only in small part to the heat of the molten veins, but rather to the steam accompanying the eruption, which could operate at some distance from the limits of the vein.

The practical result of our examination is, in brief, that one can reasonably expect to find the apatite in and in the neighbourhood of the gabbro, especially where one or more of its characteristic associates, such as rutile and the frequently described crystals of green enstatite, are found. As regards the yield of our apatite deposits, it has been found, so far, that only the deposits in the neighbourhood of the gabbro have yielded any considerable output.

Erratum.—On page 391 line 27, read 14,442 instead of 4,442.

THE

CANADIAN NATURALIST

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NATURAL HISTORY SOCIETY.

PROCEEDINGS FOR THE SESSION 1877-78.

MONTHLY MEETINGS.

1st Monthly Meeting, held October 29th, 1877.

Principal Dawson read a communication "On some Fossil Remains of Phoca Greenlandica," forwarded by Dr. Grant of Ottawa.

Mr. A. R. C. Selwyn exhibited and described a large calcareous sheath of an extinct geyser, disinterred at Three Rivers, and sent to the Museum of the Geological Survey by M. Genest.

Dr. Graham Bell's Telephone was exhibited in operation by Mr. Murray of the Canadian District Telegraph Company, and placed in communication with Emmanuel Church. The instrument was explained and illustrated by Dr. Baker Edwards, and conversations, music, &c., successfully transmitted.

2nd Monthly Meeting, held November 24th, 1877.

A paper was read by Mr. G. L. Marler on the Society's excursion to Oka, also an account of the settlements of the Indians there.

Principal Dawson read a paper "On the recent Earthquake, with an historical sketch of celebrated Earthquakes in Canada."

A very fine display of Canadian fish and game was hung in the lecture room, being a portion of the Canadian food collection prepared for the Paris Exhibition by Dr. S. P. May, and chiefly collected from the markets in Montreal during his brief

visit here. Mr. Marler made some remarks on the birds, most of which had fallen to his own gun on various occasions. Mr. Whiteaves named and commented upon the fishes exhibited.

3rd Monthly Meeting, held January 28th, 1878.

Mr. F. B. Caulfield read a paper on "The Colorado Beetle," which has since been published in the *Canadian Spectator*.

Principal Dawson presented a communication from Mr. L. S. Parker on a "remarkable form of Dendrite," resembling a fossil leaf, but formed of Tourmaline crystals. Other forms of dendrite in sandstone and in slate were also exhibited.

4th Monthly Meeting, held February 25th, 1878.

This meeting was devoted to Microscopic illustrations by members of the Microscopic Club, and the subject introduced by a brief description of the different modes of microscopic illumination, by the Recording Secretary. Messrs. McEachren, Osler, and Edwards were a Committee to arrange for the illustrations, and the students of the Colleges interested in the subject were invited through their Professors. More than thirty valuable instruments were exhibited, and the Committee were especially indebted to Messrs. Ferrier, Baillie, J. F. Whiteaves, W. Muir, E. Murphy, Dr. Wilkins, Dr. Osler and Dr. McEachren for illustrating the various modes of illumination both under high and low powers.

The meeting was well attended, and much pleasure expressed by those present.

Fifth Monthly Meeting, held March 25th, 1878.

Dr. G. M. Dawson read a paper "On the Surface Geology of the Pacific Slope of the Rocky Mountains."

He also made an interesting communication on some skulls and Indian antiquities brought by him from British Columbia, and exhibited at the meeting.

Sixth Monthly Meeting, held April 29th, 1878.

Principal Dawson read a communication from Lt.-Col. Grant, of Hamilton, on "Recent Discoveries in the Niagara Limestone." Also a paper by himself on "New Facts relating to the Geology of the Maritime Provinces."

The consideration of holding a field day was referred to the Lecture Committee.

ANNUAL MEETING.

The Annual Meeting of this Society was held on the 18th of May, 1878, and after the reading of the minutes, the President delivered the following address:

ADDRESS BY PRINCIPAL DAWSON, LL.D., F.R.S.

It becomes us in our present meeting to commemorate the names and services of eminent Naturalists associated with this Society who have passed away in the course of the year.

Dr. Philip Pearsall Carpenter was a son of the late Dr. Lant Carpenter of Bristol, and a member of a family distinguished for brilliant gifts and philanthropic enterprise. His brother, Dr. William B. Carpenter of London, and his sister lately deceased, the well known philanthropist, Mary Carpenter, need only to be mentioned in illustration of this. Dr. Carpenter was born in Bristol in 1819, and was thus fifty-six years of age at the time of his lamented decease. In 1865 he selected our city as his place of residence, and soon became one of our best known and most beloved citizens, distinguished more particularly for his fervent devotion to temperance and sanitary reform; and though much remains to be done in both of these benevolent efforts, he lived to see great good accomplished, largely by his own personal exertions.

But it was as a man of science that he was most widely known. He had devoted himself more especially to the study of the Mollusca. His collection of shells was one of the finest private collections extant, and his extensive knowledge and critical discrimination with reference to species and generic types, were unsurpassed anywhere. He was ready at all times to give aid and guidance with respect to any difficulty of determination either in recent or fossil forms; and his familiar expositions of the structures and habits of his favourites, and the way in which he made clear and intelligible their functions and modes of life, must be fresh in the memories of many of our members. We all esteemed him highly as a naturalist and loved him as a man, and we should thank him for the noble legacy he has left to our University in his magnificent collection of shells. While engaged in the work of classification and arrangement of this collection, Dr. Carpenter was occupied in preparing notes for publication on special points, and in determining and naming collections which had been placed in his hands by societies, institutions and indi-

viduals, in all parts of America. His latest special work is an elaborate revision of the difficult group of the Chitons, illustrated with figures, executed by an eminent American artist, who was induced to visit Montreal for the purpose. This paper, left unfinished at his death, will probably be published by the Smithsonian Institution.

The second name which it becomes me to mention here, is that of a man less known to many of you, but intimately known to me, and whom we have the right to claim as a Canadian geologist, and one of the highest standing—Charles Frederick Hartt, late Professor of Geology in Cornell University, and Director of the Geological Survey of Brazil, who died at Rio de Janeiro on the 19th of March last, at the early age of thirty-eight years. He was a native of Nova Scotia; and at Horton in that Province, where he studied at Acadia College, and while still a student, he became known to me as a diligent and successful collector of fossils of the Lower Carboniferous rocks. He subsequently engaged in educational work in St. John, and with his friend Mr. Matthew had the honour of fisst rendering intelligible the complicated geology of that district, and of discovering and almost exhausting its rich Devonian Flora and Cambrian Fauna. The collection and determination of the Cambrian fossils of what is now known as the Acadian group, and the excavation of the numerous fossil plants of the Devonian of the same district, constitute in my judgment two of the most important advances ever made in the palæontology of Eastern America, and are even yet bearing fruit. It was my good fortune to be able to aid and encourage Mr. Hartt in these earlier efforts, to determine his Lower Carboniferous and Devonian plants, and to afford him in my 'Acadian Geology' a medium of publication for his Primordial fossils. Acting under my advice, Mr. Hartt, in order to perfect his knowledge of palæontology, entered the school at that time recently established by Agassiz at Cambridge. This led to his appointment to a chair of geology first at Vassar College and subsequently at Cornell, and also to his connection with Brazil, which began with his being attached in 1865 to the "Thayer Expedition" to that country under Prof. Agassiz. The magnificent opening for geological work in Brazil seems to have fascinated his mind, and I remember well the enthusiasm with which he wrote to me at a subsequent time of the almost identical fauna and flora of the Brazilian coal-measures with those he

had in earlier days explored in Nova Scotia. In 1870 he returned to that country with an expedition from Cornell, and in 1875 he was appointed to the direction of the Survey then instituted by the Brazilian government, having already had a semi-official connection with the government for about a year. In the three years in which he worked in connection with the Brazilian government, he had explored and mapped large districts of the country, had accumulated a valuable geological museum, and had prepared the MS. of voluminous reports which he was about to publish at the time of his death. It is to be hoped that some worthy successor may still give them to the world.

In his character Hartt was, like our friend Carpenter, an amiable, exemplary, benevolent and christian man, and I have known few of our younger men of science who gave greater promise of brilliant success.

His rapid advancement to high and important positions shows that science is not without its advantages as a profession, and may perhaps serve to encourage others to devote themselves to similar pursuits, however such ardour may be checked by the remembrance of his early death. But it is better to live well and to good purpose than merely to live long.

Another member of this Society removed by a too early death, Dr. John Bell, deserves more than a passing notice. Taken away at the early age of thirty-three years, he had already achieved no small professional reputation, and had done good scientific work. He took the degree of B.A. in Queen's College, Kingston, in 1862, and that of M.A. in 1865. He graduated in medicine in McGill University in 1866, and in the same year took his degree of M.D. at Queen's College. After graduating he spent about a year in the army hospitals of the United States, in the vicinity of Louisville, Kentucky, and obtained the highest testimonials for his ability, industry and efficiency. He commenced practice in Montreal in 1868, and from his union of professional ability with all the highest feelings of a christian gentleman, and with all the tenderness of a sympathising heart, earned for himself not only the confidence but the love of a large and increasing number of patients. Though well informed in geology, zoology, and physical science, his favourite scientific pursuit was botany, and in this he had made large collections, and had become a reliable authority. He collected in the country around Kingston, on the Ottawa, at Owen Sound, in the Manitoulin Islands,

in Gaspe and the west coast of Newfoundland, and lists of some of these collections were published in the Reports of the Geological Survey and the *Canadian Naturalist*. He contributed many rare and interesting plants to the collections of the University and of this Society. He entered with zeal into the project of collecting a subscription for the erection of a monument over the bones of the pioneer American botanist, Frederick Pursh, and at the time of his death had succeeded in securing nearly a sufficient sum for the purpose. It is a sad coincidence that this subscription was commenced several years ago by another of our young botanists, the late Dr. Barnston, who also was removed by an early death.

Dr. Bell was a man of excellent gifts for scientific pursuits, and one whom we could have wished to give a larger amount of time to original research, but his noble and self-denying devotion to his high calling as a medical man, and especially to the relief of the poor and unfortunate, constitutes a higher claim to our regard than that which even brilliant scientific discoveries would have merited. I may add that Dr. Bell was always ready to aid our Society, and to give his valuable time to work in connection with our botanical collections.

Turning from the memory of the dead to the work of the living, I find that in all seventeen papers or communications on scientific subjects were brought under our notice in the past Session. Besides the reading of these papers, one evening was devoted to an exposition and illustration of the Telephone by Dr. Edwards and Mr. Murray; another to the exhibition of the collection of Canadian game formed by Dr. May for the Paris exhibition, and its explanation by Mr. Whiteaves and Mr. Marler, and still another to an exhibition of Microscopes and objects, for which we were specially indebted to Dr. Osler, Dr. McEachren, Mr. Ferrier, Mr. Muir, Mr. Murphy, and other microscopists. The arrangements for these meetings were made by our indefatigable Secretary, Dr. Baker Edwards, and they were all pleasant and successful.

Of the papers read the greater part were on geological subjects. Two eminent exceptions were that on the Locust in the North-West in 1876, by Dr. G. M. Dawson, and that on the Colorado Beetle by Mr. Caulfield. The former is the sequel to a series of papers on the same subject published in the *Naturalist*, and commenced when Mr. Dawson was geologist on the Boundary

Commission. On this occasion, as a private enterprise of his own, he issued circulars and blank forms to a great number of persons in the North-West, inviting replies, numbers of which were sent in from year to year. The result was the publication in our Journal of a series of papers which it is scarcely too much to say reach to all that is certainly known as to the locust plague and its remedies, and may probably be found in the sequel as important as the expensively obtained statistics now being collected by the United States Commission. I may add that not only have these reports been published in our Journal, but a large number of extra copies have been circulated throughout the West, without any expense to the country.

Mr. Caulfield's paper was an elaborate investigation of a plague which has reached nearer to ourselves. This paper has been published in one of our city newspapers, but deserves a much wider circulation. The time was when this Society was the subject of jeux d'esprit in the city press on the subject of "bug-hunting," but the Colorado beetle has vindicated the claims of the bugs to some degree of respect.

Of the geological papers, the following deserve especial mention: — the communication of Mr. Selwyn on the calcareous pipe found at Three Rivers in Post-Pliocene clays, and referred to the action of a hot spring penetrating those clays in Post-Pliocene times. That of Prof. Hind, in which he sought to illustrate the effects of Arctic ice in producing ocean currents. That of Mr. Whiteaves on new Jurassic fossils from British Columbia, in which the evidence for the existence of Jurassic rocks in that country is for the first time fully discussed. That of Dr. G. M. Dawson on the Surface Geology of the Pacific slope of the Rocky Mountains. That of Dr. Harrington on the microscopic structure of igneous dykes traversing the Laurentian rocks, one of our first Canadian contributions to Microscopic Petrology. I pass over several minor contributions, and also papers of my own on fossils from different formations, and on the Earthquake of November 10th, 1877.

On the whole our Session may be said to have been a fruitful and agreeable one, and I feel confident that the members who have attended our meetings and have looked into our published proceedings, have derived both instruction and recreation from our work. I cannot however refrain from expressing regret that our meetings have not been more largely attended, and that so

few of our members have brought under our notice facts or specimens. Surely no more rational or pleasant way of spending an evening can be found than in listening to new facts on the natural history of our country, and in examining and discussing the interesting and often rare or new specimens by which they are illustrated; and it should be borne in mind that we do not expect long or elaborate papers, but are quite content to receive the simplest and shortest notes on any natural phenomena that may be observed, or on any natural facts, either of scientific interest or of practical utility. Our Sommerville Lectures are largely attended by the public, and it appears to me that many of our monthly meetings have been of quite as great interest even to those not deeply versed in science, and vastly more so to those who are. Scientific societies in a country like this are of slow growth, but surely after an existence of half a century, and after having held up the torch of science for that long time in this community, this Society should have acquired greater strength. In the present Session it has completed its fiftieth year, and I think that it is time its members should make greater efforts to revive and strengthen it, so that it may be able with some vigour and eclat to celebrate its jubilee.

The address of the President was followed by the Report of the Chairman of Council, Mr. G. L. Marler, as follows:

REPORT OF THE CHAIRMAN OF COUNCIL.

At the close of another Session your Council beg to submit the following *résumé* of proceedings during the past year.

There has been little of extraordinary moment to which to call the attention of the members, but it may be stated that the labours of the Society seem to have been better appreciated than in the past, and also that there has been a larger attendance at the Sommerville Lectures and more visitors to the Museum.

The usual field day was a success in point of numbers, about 109 persons having been present. The trip was a very enjoyable one, as the weather was bright and pleasant. The party went by rail to Lachine, thence by boat up the river St. Lawrence, past Ile Dorval to Ile Perrot, where the boat stopped for a couple of hours to enable the excursionists to gather botanical specimens. The steamer then proceeded up through the Lake of Two Mountains to Oka, at which place the stay was too short, there not being sufficient time left for the ascent of

Mount Calvary. As usual the receipts were scarcely sufficient to meet the expenses.

In order to carry out the recommendation of the Report of the Council of the previous year, concerning the appointment of a competent Scientific Curator to devote most of his time to the museum and library, Mr. F. B. Caulfield was engaged at a salary of $200. Since his engagement he has been devoting himself to his work to the satisfaction of the Council.

Your Council have to report that thirty-two new members have been added to the Society, but they greatly regret the loss of Dr. Philip P. Carpenter and Dr. John Bell, to whose death the President has alluded in his address. In them the Society loses two of its most active members.

The papers read at the usual monthly meetings have received full attention in the President's address, and call for no further mention from your Council.

The Sommerville Lectures have been delivered as usual, and were highly appreciated by the members of your Society and the public, the attendance having been much larger than formerly. The subjects of the lectures were as follows:

1. Feb. 7. On Insects, their Habits and Habitats: By the Rev. T. W. Fyles, illustrated by Microscopic Photographs taken and projected by Mr. Charles Baillie.
2. Feb. 14. On the Eye and its Mechanism. By Dr. Buller.
3. Feb. 21. On Glaciers, past and present, and the work they perform. By Dr. C. A. Wood.
4. Feb. 28. On the Ear and its Mechanism. By Dr. Proudfoot
5. Mar. 7. On a visit to River de la Plata; its scenery, resources and local constitution. By Dr. Blackader.
6. Mar. 14. On Health. By Professor Bovey.

On the evenings of the lectures the museum was thrown open to the public, and was visited by about two thousand persons, in addition to one thousand visitors at other times during the year; a much larger attendance than there has ever been before. The greater portion of these were admitted to the museum free of charge.

The rooms have been rented during the year to several kindred societies, &c., and realized as rent the sum of $600.

The vestibule of your building has also been greatly improved by closing the space on the left going in and the stairway.

The Reports of the Scientific Curator, Mr. F. B. Caulfield, and of the Library Committee, were then read.

REPORT OF THE SCIENTIFIC CURATOR.

During the past year the donations to the museum have not been very numerous. A fine specimen of the Carolina Grey Squirrel, *Sciurus Carolinensis*, and six species of Canadian birds have been presented; also a specimen of the Snow Goose, *Anser hyperboreous*, and a fine pair of the common Gar Pike, *Lepidosteus osseus*, has been purchased.

The entomological collection has been re-arranged and classified, and measures have been taken to prevent injury from the larvæ of *Dermestes*, &c. The number of species in the local collection of Coleoptera has been largely increased by collections made and presented by Mr. Whiteaves and Mr. Passmore, and by duplicates from my own cabinet. The valuable series of beetles collected in British Columbia by Mr. Selwyn and Prof. McCoun, and determined by Dr. LeConte of Philadelphia, have also been labelled and pinned into their proper place in the cabinet.

The Diurnal Lepidoptera, Sphingidæ, and part of the Noctinidæ, have been classified and labelled, but owing to want of space the whole of the remaining families of smaller nocturnal moths cannot be exhibited. The Orthoptera are also nearly all named, and along with a large series of Hymenoptera, Hemiptera, Neuroptera and Diptera, are ready for exhibition as soon as another cabinet can be provided.

In the last annual report of my predecessor, Mr. Whiteaves, it was stated that "although corrosive sublimate was mixed with the paste with which the plants are fastened to the papers, it has been recently noticed that a small beetle has been and is still making burrows through some of the fasciculi, and the matter requires immediate attention." On examining the herbarium, it was found that many of the plants had been attacked by the larva of a small beetle, *Anobium foveatum*. Every plant was separately examined and the grubs removed and destroyed. Camphor has been placed in the herbarium and strips of cotton velvet fastened on the edges of the doors, so as to make them fit as tightly as possible; and it is believed that as the plants were examined at the season when the insect was in the larval condition and easily detected, the herbarium has been thoroughly freed from them, and with a little care can be kept in good order.

Many of the plants, however, are old and worthless, and should be replaced by fresh specimens as soon as they can be obtained.

Some of the jars containing Fish and Reptiles have been refilled with alcohol, but a larger supply is needed, especially for the collection of marine invertibrates.

The cases containing the Mammalia, Birds, Fish and Reptiles need re-papering, as they are badly stained and discolored. The glass fronts of the cases should also be washed, and the floors throughout the museum more frequently scrubbed, as the dust which accumulates is very injurious to the specimens.

All donations to the museum and library have been recorded, and the circulars for the monthly meetings have been regularly addressed and posted. F. B. CAULFIELD.

REPORT OF THE LIBRARY COMMITTEE.

The Library Committee have to report that although few meetings have been held during the year, the condition of the library has been considerably improved.

About twenty-five volumes of various scientific journals have been bound and are now on the shelves, while twenty-seven more have been arranged and are now in the hands of the binder.

A good deal has also been done in the way of collecting together the scattered numbers of some of the more important journals, transactions, &c., and a list of them has been prepared by Mr. Caulfield to show what numbers are in the library and what missing. The proportion of the latter is unfortunately large, and there are very few journals of which complete volumes can be made up for any number of consecutive years.

There are now about 1333 bound volumes in the library, classified by Mr. Caulfield as follows:—

Botany	96 vols.
Chemistry	37 "
Geology and Mineralogy	64 "
Natural History in General	280 "
Philosophy and General Science	91 "
Voyages, Travels, &c.	50 "
Biography and History	44 "
Miscellaneous	115 "
Periodicals, Reports of Scientific Societies &c.	556 "
Total	1333

The accompanying statement was then submitted by the Treasurer, Mr. E. E. Shelton:

Dr. THE NATURAL HISTORY SOCIETY OF MONTREAL, *in account with* E. E. SHELTON, *Treasurer.* *Cr.*

1877-78.	*Recapitulation.*	
To Cash paid	Mr. Cauldfield's Salary	$150.00
"	Mr. Passmore's "	400.00
"	" for attendance	8.00
"	Mr. Foote, commission on collections	11.50
"	Coal and Wood	108.51
"	Gas Bills	89.90
"	Water	43.95
"	City Taxes	116.40
"	Insurance	36.05
"	Repairs and Petty Expenses	103.03
"	Printing and Advertising	113.10
"	Interest Royal Institution	77.50
To balance in Treasurer's hands		282.97
		$1540.91

1877-78.	*Recapitulation.*	
By Balance in Treasurer's hands		$708.41
" Cash received, Members' Yearly Subscriptions		245.00
" "	Entrance Fees	18.50
" "	Rent of Rooms	569.00
		$1540.91

LIABILITIES.

Mortgage on Society's Buildings in favor of Royal Institution	$1000.00
Balance, Dawson Brothers	175.00

MONTREAL, 17th May, 1878 } Audited and found correct, after comparing Vouchers, &c.
G. L. MARLER.
W. MUIR.
J. H. BRISSETTE.

Mr. W. Muir moved, seconded by Mr. J. B. Goode, "that the reports now read be received, approved and printed in pamphlet form for distribution to members."

Moved by Mr. G. L. Marler, seconded by Mr. Shelton, "that the by-laws relating to the election of officers be suspended, and that Principal Dawson be re-elected President of the Society." Carried unanimously.

Moved by Mr. Marler, seconded by Dr. Harrington, "that Mr. E. E. Shelton be re-elected Treasurer." Carried unanimously.

Moved by Dr. Dawson, seconded by Mr. Joseph, "that Dr. Baker Edwards be re-elected Recording Secretary, and Mr. Frank W. Hicks Corresponding Secretary." Carried unanimously.

Moved by Dr. Edwards, seconded by Mr. Marler, "that Mr. F. B. Caulfield be re-elected Scientific Curator for the ensuing year." Carried unanimously.

Moved by Mr. Marler, seconded by Mr. J. H. Joseph, and carried, "that the Council be requested to make suitable arrangements for the Editorship of the *Naturalist* and report to the Society."

Messrs. J. B. Goode and Brissette having been appointed scrutineers, the following gentlemen were elected by ballot:

Vice-Presidents—Rev. A. DeSola, LL.D.; A. R. C. Selwyn F.R.S.; G. L. Marler, Esq.; Prof. P. J. Darey, M.A., B.C.L.; James Ferrier, Jr., Esq.; J. F. Whiteaves, Esq., F.G.S.; C. Robb, Esq.; Rev. Canon Baldwin; J. H. Joseph, Esq.

Council—W. Muir, Esq., J. H. Brissette, Esq., Dr. B. J. Harrington, J. B. Goode, Esq., Prof. R. Bell, Dr. Osler, R. W. McLachlan, Esq., Dr. D. McEachren, Dr. G. M. Dawson.

Library Committee—Dr. B. J. Harrington, Convener, Dr. McConnell, Mr. Joseph Bemrose, Mr. J. Fraser Torrance, Mr. Charles Baillie.

A vote of thanks to the retiring officers closed the proceedings.

The Recording Secretary announced that the Annual Excursion would take place on the 1st of June, to St. Jerome, and the usual prizes would be offered for the best field collections.

DONATIONS TO MUSEUM AND LIBRARY—SESSION 1877-78.

From	TO THE MUSEUM.
N. P. Leach, Esq.	Carolina Grey Squirrel, *Sciurus Carolinensis.*
	White-throated Sparrow, *Zonotrichia albicollis.*
	Red-winged Blackbird, *Agelaius Phœniceus.*
	Ptarmigan, *Lagopus albus.*
	White-bellied Swallow, *Hirundo bicolor.*
J. C Stockwell, Esq.	Northern Phalarope, *Phalaropus hyperboreus*
	Caterpillar of Moth. *Samia Columbia.*
G. W. Stephens, Esq.	Three stuffed Ptarmigan. *Lagopus albus.*
J. F. Whiteaves, Esq.	A series of the Coleoptera of the Island of Montreal.
Mr. Passmore.	A series of Coleoptera & Lepidoptera of the Island of Montreal.
Master Arthur Weir, and Master Frank Mitchell.	A number of Indian bones, dug up in a field between Peel and Metcalfe Streets, Montreal.
By Purchase.	Snow Goose, *Anser hyperboreus.*
	Pair common Gar Pike, *Lepidosteus osseus.*
	TO THE LIBRARY.
The High Commisson of Brazilian National Exhibition.	Brazilian Biographical Annals, 3 vols.
The Trustees of the British Museum.	List of the Lepidoptera Heterocera in the British Museum, Part 1.
	Catalogue of British Hymenoptera Part 1.
	Catalogue of Birds, Part 3.
	Catalogue of Fossil Reptiles of South Africa.
	British Fossil Crustacea (list of).
	Gigantic Land Tortoises.
	Guide to the Departments of Natural History and Antiquities in the British Museum.
J. M. LeMoine, Esq.	Tableau synoptique des Oiseaux du Canada
	Catalogue of Birds, Fishes, Reptiles, Woods &c., in the Museum of the Literary and Historical Society of Quebec.
A. H. Foord, Esq.	D'Orbigny's Palæontology, 2 vols.
	Quarterly Journal of Geological Society of London 3 vols.
J. F. Whiteaves, Esq.	Owen's Palæontology, 2nd Edition.
Principal Dawson.	Acadian Geology, 3rd Edition.

GRAPTOLITES OF THE NIAGARA FORMATION.

By J. W. Spencer, B.A., B.A.Sc., PhD., F.G.S.

For many years, forms of life, allied or belonging to the Graptolite family, have been known to occur in several places throughout portions of the Niagara formation of New York. In the second volume of the Palæontology of New York, Prof. Hall has described three species, and lately one has been described by Professors Hall and Whitfield in the Palæontology of Ohio, all of which have been also obtained at Hamilton. The ancient seas of Hamilton, Ontario, appear to have been very favourable to their growth, as they have been found more abundantly here than elsewhere. Among the large number of specimens obtained nearly twenty species occur. Of these the writer has recognized four mentioned below, and has ventured on the description of three new genera and nine new species, hoping to complete the work with descriptive plates at an early date.

Whilst the Graptolites of other formations generally occur in shales, those at Hamilton more frequently are found in the limestones. Yet those obtained in the shales have their structure better preserved. In most cases the polyparies are obscured, but some of the specimens show their cells on one side. The corneous structure is often well preserved, as also the corrugations and depressions on the stipe. Different forms appear to be characteristic of different beds of rock. As the various species show great varietal differences, much difficulty arises in the way of the student, and many fragments that appear at first sight to be unlike, are found on close examination to belong to others whose characters are recognized, or are too irregular in their forms to establish specific relations.

For six years I have been making a collection of Graptolites whilst geologizing with my friend Lieut.-Col. Grant, H. P. 16th Regt. But it is principally owing to the indefatigable researches of that gentleman that so many Graptolites have been obtained, and many that are in my collection of over 200 specimens were collected by him. The earlier collections made by Col. Grant were sent to the Geological Survey of Canada, and later to Principal Dawson, LL.D., F.R.S., of McGill University. To both of these collections access was afforded. The types are at present at the Canadian Geological Survey Office.

Without further mention of the interesting associations of the Graptolites at present, the writer respectfully submits the notice of a few species found at Hamilton.

Genus *Dictyonema*, Hall, Palæontology of N. Y., Vol. II.
D. retiformis, Hall, " " "
D. gracilis, Hall, " " "
D. tenella, n. s.

Genus *Calyptograpsus*, n. g.
C. cyathiformis, n. s.
C. subretiformis, n. s.

Genus *Rhizograpsus*, n. g.
Rh. bulbosus, n. s.

Genus *Inocaulis*, Hall, Palæontology of N. Y., Vol. II.
I. plumulosa, Hall, " " "
I. bella, Hall & Whitfield, Palæontology of Ohio.
I. (?) *problematica*, n. s.

Genus *Acanthograpsus*, n. g.
A. Granti, n. s.

Genus *Ptilograpsus*, Hall, Can. Organic Rem. Decade II.
Pt. foliaceus, n. s.

Genus *Callograpsus*, Hall, " " "
C. Niagarensis, n. s.

Genus *Thonnograpsus*, " " "
Th. Bartonensis, n. s.

Genus DICTYONEMA, Hall, Palæont. N. Y., Vol. II.

Dictyonema tenella, n. s.

Frond cyathiform in growing state, but usually circular, although occasional specimens have a flabellate form in the rock. The branches are uniform, nearly parallel, and radiate from the centre with very few bifurcations; in width they vary from $\frac{1}{120}$ to $\frac{1}{80}$ of an inch, but uniform in the same specimen. The branches are connected at short intervals by transverse dissepiments; while the margin of the frond is remarkably constant. The surface is striated, and the texture has a corneous character like that of the other species of this group.

As the connecting filaments are very fine, owing to imperfect preservation, they are not always distinct over the whole surface

of the frond. This species is easily distinguished from *D. gracilis*—even in fragments—by the branches being exceedingly fine (about one-hundredth of an inch in width), with scarcely that distance between them, and with no approach to the dendritic form of that species. The frond maintains its character even in the young state. The largest frond is three and one-half inches in diameter.

It occurs in the Niagara limestone at Hamilton, Ontario. The specimen described was obtained by Lieut.-Col. Grant, and presented to the writer.

Genus CALYPTOGRAPSUS, n. g.

Gr. *kaluptos*, overlaid; *grapho*, I write.

Frond cyathiform, with numerous bifurcating branches, which are dichotomous at their terminations, but are not connected by lateral processes. The branches are marked with striæ resembling rhomboidal pits; the axis has a black corneous exterior, and the radicle is composed of a thickened mass of the same texture as the branches. In appearance and texture this genus resembles Dictyonema, but the branches are all independent, not being connected by transverse dissepiments as in that genus, and are only united in one mass at the root. When fallen some of the branches overlie others as in a semi-anastomose form; the general shape of the frond is circular.

Calyptograpsus cyathiformis, n. s.

Frond cyathiform, with numerous bifurcating branches, united only at the base, with no lateral processes; the axis consists of a black corneous substance, which is striated longitudinally. The fallen frond has some of the branches overlying each other, forming a coarse net work. The radicle consists of a well marked, thick, corneous mass.

The branches are about three-hundredths of an inch in breadth. The specimen under consideration is most interesting. When obtained the frond had a general flabellate form with the radicle well marked, having branches radiating to nearly a semi-circle; but on trimming the specimen the portion of the stem with radicle was chipped off, and revealed the remainder of a beautiful frond which was now shown to be circular—thus proving the funnel-shaped character when living. This fossil is two and one-half

inches in diameter, and from the base of the root to the top of the branches it measures one inch and a half.

It occurs in the Niagara limestone at Hamilton, Ontario.

Calyptograpsus subretiformis, n. s.

Frond circular, but cyathiform in its growing state. There are numerous bifurcating branches, which in the fossil condition imperfectly unite or overlie each other, producing a kind of fine net-work with irregular sub-rhomboidal interstices. In texture it is corneous, having the branches marked with striations of a sub-rhomboidal form.

In this species the branches are much finer (but little more than one-eightieth of an inch in width) than in *C. cyathiformis*, with more numerous and irregular bifurcations, producing a netted appearance. The original matter is often replaced by pyrites. The fronds are not generally more than two inches in diameter. Only a few specimens have been found, and these show some varietal differences.

This species was found in the Niagara limestone, Hamilton, Ontario, by Col. Grant.

Genus Rhizograpsus, n. g.

Gr. *Rhiza*, a root; *grapho*, I write.

Frond flabellate, but cyathiform in growing state; bifurcating branches with dichotomous terminations; stem terminating in a well-marked bulb; branches (marked with striæ) more or less reticulated, and united, or overlaid by others.

This genus is established on account of its *bulbous root*, which as yet has been found in no other species of this family. The numerous branches closely overlie each other or are connected in the form of a net-work without transverse dissepiments, as in Dictyonema. Fragments of these somewhat resemble species of Calyptograpsus, but have a much more netted appearance and the branches are much more delicate.

Rhizograpsus bulbosus, n. s.

Frond cyathiform in growing state; numerous bifurcating branches overlie each other, or are united at point of contact to form a net-work, with fine, more or less irregular, rhomboidal interstices. The branches unite at base into a slender axis which terminates in a bulbous root. The branches are usually

less than $\frac{1}{50}$ of an inch wide, and in some specimens short abrupt spine-like branchlets are given off. The texture is corneous. Only a few specimens have been obtained, except in fragments. Frond is about two inches high. It was first found by Col. Grant in the Niagara limestones at Hamilton, Ont.

Genus INOCAULIS, Hall, Palæont. N. Y., Vol. II.

Inocaulis (?) problematica, n. s.

Plant-like, with numerous slender bifurcating branches, radiating more or less from a common centre, and resembling the branches of rootlets; texture corneous with irregular corrugations.

This species is of common occurrence, and is not easily mistaken for any other. The texture is not well preserved, appearing often as mere stains of dark color on the surface of the stone. Its relations are somewhat doubtful, but it is easily distinguished from all the other species of the family by its root-like character and slender branches (one-fortieth of an inch), often overlapping each other in an irregular manner. It occurs abundantly in the Niagara limestones of Hamilton, Ontario.

Genus ACANTHOGRAPSUS, n. g.

Gr. *Akantha*, a thorn; *grapho*, I write.

Frond shrub-like, consisting of thick branches, principally rising from near the base, with little divergence and some bifurcations. One side of the branches is furnished with prominent spines or dentacles, which appear to mark the cell-apertures. Texture corneous and indistinctly striated. This generic form resembles *Dendrograpsus*, but it is stronger and more bushy than species of that genus, and has conspicuous spines indicating a different cell structure.

Acanthograpsus Granti, n. s.

Frond shrub-like, with thick branches principally originating near the base. Some of the branches are bifurcated, and have the ends dichotomous; cell apertures on one side only, and indicated by prominent spines which appear to be placed below them. The branches are sometimes the sixteenth of an inch broad, with spines in some places projecting the twenty-fourth of an inch and ending abruptly.

The larger fronds do not exceed two inches in height, and sometimes have the same width.

This species was first obtained at Hamilton, Ont., by Col. Grant.

Genus PTYLOGRAPSUS, Hall, Can. Org. Rem. Dec. II.

Ptylograpsus foliaceus, n. s.

Frond bipinnately branching. The slender branches are plumose, with delicate pinnules rising alternately from the opposite sides of the branchlets. There are angular openings on one side of the pinnules, whilst on the other there are indistinct corrugations. When viewed from the face, the cellules appear as oval impressions.

The branches seldom exceed more than half an inch in length and all appear to originate from nearly the same place on the axis. From these numerous parallel pinnules occur on each side of the axis (sometimes as many as sixteen). The pinnules seldom exceed the fourth of an inch in length and rise at a very acute angle. Even if separate branches be found they are easily recognized. They appear to have been attached, but from the specimens before me the radicle seems to have been broken off.

Like the other members of this group the texture is corneous, but sometimes replaced by pyrites. This species closely resembles the *P. plumulosa* of the Quebec Group, but is smaller (three-fourths of an inch) and finer in structure, with the relatively longer pinnules.

It occurs in the Niagara Limestone at Hamilton, Ontario.

Genus THAMNOGRAPSUS, Can. Org. Rem. Dec. II.

Thamnograpsus Bartonensis, n. s.

Stipes single and broad with lineal undulating branches alternately arranged on opposite sides and having half the thickness of the stipe, which is as much as one-sixteenth of an inch broad. The branches which are given off, are usually at right angles with the stipe, and are generally half an inch apart; there being an undulation of considerable length, opposite to their place of attachment.

Texture corneous and black, the surface being nearly smooth with longitudinal depressions. The branches are usually short and abrupt.

They occur in the Niagara Limestone at Hamilton, Ontario, and the writer has seen them in the rock several inches long.

Genus CALLOGRAPSUS, Can. Org. Rem. Dec. II.

Callograpsus Niagarensis, n. s.

Frond flabellate; the slender bifurcating branches more or less parallel with occasional transverse filaments. The form is nearly semicircular with the branches radiating from a common axis. In texture it is corneous and the surface of the numerous flattened branches is marked with striations, appearing like oval impressions, while on the under side there are minute pits indicating the apertures of the cells, as many as twenty pits being visible in one-fourth of an inch. The fronds are usually less than two inches in breadth, and resemble the outline of a bush, where the branches principally originate from the root.

This species is easily distinguished from *Dictyonema* by the bush-like form and more slender branches, together with an almost entire absence of dissepiments and cell markings. In the better preserved specimens, the cells readily distinguish it from *Dendrograpsus*, as also the more numerous and more parallel branches. The branches are broader, more drooping and further separated than in the species of this genus found in the Quebec Group.

Besides the species described above the writer has observed several species of *Dendrograpsus* and others, which he hopes to publish at an early period with plates, and more particulars of their modes of occurrence and general structure.

ON SOME MARINE INVERTEBRATA FROM THE WEST COAST OF NORTH AMERICA.

By J. F. Whiteaves.

During Mr. Richardson's explorations on Vancouver Island and the coast of British Columbia, on behalf of the Geological cal Survey of Canada, in the summer seasons of 1874 and 1875, no opportunity was neglected for obtaining specimens of interest to the zoologist or botanist. In the first of these years, an examination of the coast was made, from Victoria, V. I., to the mouth of the Stickeen River in Alaska, as described in the "Report of Progress for 1874–75," and some dredging was done in Burrard's inlet, also in McLaughlin's bay on Campbell Island. The following year, in addition to shore collecting near Victoria, successful dredging operations were carried on in the Gulf of Georgia, between Victoria Harbour and Race Island Lighthouse, also in Deep Bay opposite Denman Island, and near the north-west end of Texada Island. A small but interesting series of littoral Algæ, Hydroids, Polyzoa and Crustaceans, from the immediate vicinity of Victoria, was presented to the museum of the Survey, through Mr. Richardson, by Mr. R. Middleton, of that city, in 1875. The whole of the zoological specimens obtained during these two years were deposited temporarily in the Museum of the Natural History Society of Montreal, with the understanding that the writer, who was then Curator to the Society, would examine and report upon them.

The Crustacea, with the exception of the *Echidnocerus*, have been kindly determined by Prof. S. I. Smith, and the Hydrozoa by Prof. S. F. Clark, both of Yale College. The writer is also indebted to Professors Verrill and A. Agassiz, and to Mr. W. H. Dall for valuable assistance in the identification of some of the Alcyonaria, Echinodermata and Mollusca.

The following is a list of the species recognized so far.

Hydrozoa.

Littoral species, collected near Victoria by Mr. R. Middleton.

Aglaiophenia struthionides.
Plumularia setacea.
Sertularia anguina, Trask, var. *robusta.*
Sertularella Greenii.
" *turgida*, Trask.
Obelia. (Sp. Undt.)
Tubularia. (Sp. Undt.)

Alcyonaria.

Verrillia Blakei, Stearns. Five fine living specimens of this gigantic and remarkable Pennatulid were obtained by Mr. Richardson from Burrard's Inlet, in between 10 and 20 fathoms, in 1874. These have since been received in a beautifully perfect state of preservation, as alcoholic preparations, but Mr. Stearns' description of the species (on pages 147 to 149 of the fifth volume of the "Proceedings of the Californian Academy of Sciences") is so exhaustive and accurate, that they give very little additional information on the subject. The largest specimen collected by Mr. Richardson is seven feet and eight inches long, the length of the naked basal portion being just two feet. The polyps, which are sessile, are arranged in crowded, subimbricating, obliquely transverse rows, "in two unilateral longitudinal series." Mr. F. B. Caulfield has carefully counted the exact number of polyps in one of the longitudinal series in this specimen and finds it to be 3802; the number of transverse rows in the same series, including the shortest ones, being 369. On the supposition that there is an equal number in both series, the total number of polyps in this individual would be 7604! In a specimen 66 inches long, described by Mr. Stearns, it has been estimated that there would be about 5000.

It would appear that this or a very similar species is found also off the coast of Alaska, for in a letter by the anonymous author of the quaint narrative of the voyages of the King George and Queen Charlotte, published under the

name and authority of Captain Dixon,* dated Montague Island (Prince William Sound) May 13, 1787, the following passage occurs: "I should not omit that one of our people, in fishing with hook and line, caught a very remarkable object, which I suppose to be a species of polypus: it seemed to be both of an animal and vegetable nature, and adhered to a small switch about three feet long."

Paragorgia. (Nov. Sp. ?) A living example of a large and multitudinously branched, spreading species of *Paragorgia* was purchased by Mr. Richardson in 1875 from some fishermen, who informed him that it was brought up on one of their lines from a depth of about ten fathoms in Jervis Inlet. A portion of one of the branches and a photograph of the specimen have been sent to Prof. Verrill, who thinks that the species is closely allied to the *Paragorgia arborea* of the Northern Atlantic Coast, but that it is probably new to science.

Echinodermata.

Ophioglypha Lutkeni? Lyman. Two brittle stars which seem referable to this species, were dredged by Mr. Richardson in two different localities in the Strait of Georgia in 1875.

Cribrella lævisculca. Stimpson. Strait of Georgia, two living specimens: J. Richardson, 1874.

Pycnopodia helianthoidea, Brandt. (Sp.) Creeping on stones near low water mark at the entrance to Deep Bay, V. I.; J. Richardson, 1875.

Asterias epichlora? Brandt. Low water near Victoria, V. I.; J. R., 1874. Rays five, very long and slender, disk small. Greatest diameter, from the extreme points of two opposite rays, sixteen inches: breadth of disk, scarcely two inches. Dorsal spines short, cylindrical or subclavate, truncated at their summits, rather sparse, and forming distinct but irregular reticulations. Ventral spines much longer and more crowded.

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* A Voyage round the World, but more particularly to the North West Coast of North America, performed in 1785, 1786, 1787 and 1788 in the King George and Queen Charlotte, Captains Portlock and Dixon. By Captain George Dixon. London, 1789. Page 148.

Asterias ochracea? Brandt. Gulf of Georgia, in from twenty to seventy fathoms. One living specimen: J. Richardson, 1875. Rays five, rather long and tapering gradually, disk somewhat small. Maximum diameter, three inches and a quarter: breadth of disk, three-quarters of an inch. Dorsal spines cylindrical below, bluntly pointed and longitudinally grooved above, thinly scattered and not forming very distinct reticulations. Ventral spines similar to the dorsal, but much more crowded. As the writer has not access to Brandt's original description of this and the preceding species, their identification, which is based upon Stimpson's short summary of their characters in volume six of the Journal of the Boston Natural History Society, is uncertain.

Asterias hexactis? Stimpson. One specimen, from the same locality and station as the preceding: J. R., 1874. Rays six, short and tapering rapidly: disk large. Greatest diameter, twenty-one lines: breadth of disk, eight lines. Dorsal spines small, short, numerous, arranged in five or six longitudinal rows, equal in height, cylindrical, minutely fluted, and subtruncated above. Ventral spines much longer, dilated at their summits, and apparently smooth or nearly so.

Dendraster excentricus, Esch. (Sp.) Abundant in shallow water near Deep Bay, V. I.: J. R., 1875.

Loxechinus purpuratus, Stimps. Sooke, in the Strait of Juan de Fuca, in one or two fathoms: J. R., 1874.

Toxopneustes Franciscana, A. Ag. Same locality and collector as for the preceding species.

Pentacta. Sp. undt. Gulf of Georgia in from 20 to 70 fathoms. J. Richardson, 1875.

Polyzoa.

The marine Polyzoa collected by Messrs. Richardson and Middleton have yet to be studied. Most of the species appear to be new, and of those which have been previously described only the three following have been recognized at present.

Tubulipora phalangea, Couch. In dead shells at low water mark near Victoria: J. R., 1874.

Membranipora lineata, Linn. var. With the preceding.

Flustra membranacea, Johnston, as of Linnæus. Not *Membranipora membranacea* of Johnston or Busk. Near Victoria; R. Middleton, 1875.

Brachiopoda.

The Brachiopoda named below were dredged by Mr. Richardson between Race Island Lighthouse and Victoria Harbour in from 30 to 70 fathoms, and off the N. W. end of Texada Island, in 40 to 70 fathoms mud, with the exception of the *Megerlia* which was taken only at the first mentioned locality.

Hemithyris psittacea, Linn. (Sp.) Several. Alive.

Terebratulina unguicula, Cpr. Rather abundant. Loop complete.

Laqueus Californicus, Dall ex Koch. Four living specimens. Identified by W. H. Dall.

Terebratella transversa, Sby. (= T. caurina, Gld.) Seven living examples.

Megerlia Jeffreysi, Dall. One dead but perfect shell. Also identified by Mr. Dall. The species was originally described from Alaska.

Mollusca.

Name of Species.	Number of Live Specimens.	Number of Dead Shells.	Remarks.
(*Lamellibranchiata.*)			
Neæra pectinata, Cpr.	1		
Kennerlya grandis, Dall.		3	Recently described from Unalashka.
Lyonsia Californica, Con., variety bracteata		1	A single valve.
Psephis Lordii, Baird.	Many		Found abundantly also at Klio Bay, in 12 fathoms by J. Richardson in 1874.
Venus Kennerlyi, Reeve	1		
Cardium Nuttalli. Con.	Many		
Cardium Richardsoni, (N. Sp.)*	1		For description of this species see the foot note below.

* Cardium Richardsoni, N. Sp. Shell inflated, but not quite as thick as high, inequilateral; outline transversely and ovately subcircular, length slightly exceeding the height; posterior side rather longer, and more narrowly rounded than the anterior: beaks large, elevated, incurved and approximating; placed a little in advance of the middle. Surface of the anterior and central portions of the shell marked by flattened and comparatively broad, radiating ribs, separated by narrower, deeply impressed lines, both of which are crossed by faint, concentric striæ or lines growth. On the posterior area, the radiating ribs are thin, prominent, and much narrower than the flattened interspaces, and the concentric striations are developed into elevated, thin and crenulated laminar ridges. Hinge with two small cardinal and two remote lateral teeth in each valve, one of which is sublunular. Pallial line entire; inferior margin of the valves denticulated all round within. Valves touching at all points when closed; not open at either extremity.

Length of the only specimen yet obtained, eight lines and a quarter: height seven lines and a half; thickness through the closed valves, not quite six lines.

Strait of Georgia, between Race Island Lighthouse and Victoria Harbour, in 30 to 50 fathoms.

Name of Species.	Number of Live Specimens.	Number of Dead Shells.	Remarks.
Serripes Laperousianus, Desh.	1		
Rhectocyma mirabilis, Dall....	8		Perhaps = Astarte Esquimalti, Baird.
Lucina tenuisculpta, Cpr.....	Many		
Modiolaria lævigata. Gray.....	2		
" nigra, Gray	1		New to the W. Coast of N. America.
Axinea septentrionalis, Midd .	1		
Nucula tenuis, Mont.....	1		
Acila Lyalli, Baird.....	5		
Leda minuta, O. Fab.....	1		
Yoldia lanceolata, J. Sby.....	3		
Yoldia amygdala, Val.....	2		
Pecten hastatus, Sby. variety Hindsii, Cpr.....	1		Mr. Dall thinks that both of these are varieties of Pecten Islandicus.
Pecten hastatus, Sby, variety rubidus, Hinds.....	1		
Amusium caurinum, Gld	4		18 to 20 fathoms, Deep Bay, about 130 miles N. of Victoria: not found at the other two localities.
(*Gasteropoda.*)			
Tornatina eximia, Baird.....	3		
Dentalium rectius, Cpr.....	1		A fine, adult specimen.
Lepeta cœcoides, Cpr.....	2		
Glyphis aspera, Esch	4		
Puncturella galeata, Gld	1		
Calliostoma annulatum, Mart.	4		
Margarita pupilla, Gld, variety inflata, Cpr.	2		Umbilicus closed.
" Vahlii, Moll.....	1		
" lirulata, Cpr	1		
Crepidula navicelloides, Nutt..	2		
Galerus fastigiatus, Gld	4		
Mesalia reticulata, Migh.....	1		=M. lacteola, Cpr.
Drillia cancellata, Cpr.....	1		
Bela fidicula, Gld.....	1		
Surcula perversa, Gabb.....	2		Very fine.
Eulima micans, Cpr.....	Many		
Trichotropis cancellatus, Hinds	3		
Natica clausa, Brod. & Sby....	1		
Lunatia pallida, Brod. & Sby .	3		Probably=L. Groenlandica, Moll.
Priene Oregonensis, Redf.....	2		
Olivella bætica, Cpr.....	Many		
Nassa mendica, Gld...	4		
Amphissa corrugata, Reeve....	3		
Trophon Orpheus, Gld.....	1		
" tenuisculptus, Cpr...	2	8	
" muriciformis, Dall ...	2		"Icy Cape; Smith. Bering Sea; Dall."
Chrysodomus dirus, Reeve.....	1		
" tabulatus, Baird,.....	3	2	
" rectirostris, Cpr.....	3		

Littoral species collected near Victoria, V. I., by J. Richardson in 1875.

Name of Species.	Number of Live Specimens.	Number of Dead Shells.	Remarks.
(*Lamellibranchiata.*)			
Pholadidea penita, Con.....	4		Siphonal tube wrinkled but not tuberculated.
Pholadidea ovoidea, Gld.....	4		Siphonal tube tuberculated externally, especially near the middle.
Saxicava pholadis, Linn.....		3	
Cryptomya Californica, Con...	1		
Schizothærus Nuttalli, Con....		Valves.	
Solen sicarius, Gld..... ...		1	
Mæra salmonea, Cpr.....	Several		
Tapes staminea, Con.....	do.		
Saxidomus squalidus, Desh. ..	1		
Petricola carditoides, Con.....	4		According to Tryon this is *P. nivea*, Chemn.
Mytilus edulis, Linn.....	2		Young.
Modiola modiolus, Linn.		1	
Hinnites giganteus, Gray.....	2		
Placunanomia macroschisma, Desh.....	6		
(*Gasteropoda.*)			
Cryptochiton Stelleri, Midd. ..	1		
Katherina tunicata, Sby	2		
Tonicella insignis, Reeve.....	1		=Tonicella submarmorea, Midd.
" lineata, Wood.....	2		
Mopalia ciliata, Sby.....	1		=Chiton muscosus, Gld.
" Merckii, Midd.....	1		=Chiton lignosus, Gld.
" " " variety vespertina.....		1	
" Hindsii, Gray	2		
Acmæa patina, Esch.....	Several		
" pelta, Esch.	do.		
Littorina scutulata, Gld. variety plena.....	1		
Natica russa, Gld.....		1	Apparently a large variety of *N. Clausa*.
Amycla gausapata, Gld	3		
Purpura crispata, Chemn.....	Many		
" saxicola, Val., variety lurida.....	1		
Buccinum polare, Gray, variety compactum, Dall....		2	Teste Dall.
Cerostoma foliatum, Gmel.....		3	

Crustacea.

Dredged at McLaughlin's Bay, Campbell Island, in from ten to thirty fathoms, by J. Richardson, in 1874.

Chorilia longipes, Dana. One.

Dermaturus hispidus, Stimpson. One.

Paracrangon echinatus, Dana. Three.
Crangon salebrosus, Owen. One.
Hippolyte Ochtoensis? Brandt. One, broken.

("This last species is quite uncertain, as the specimen is imperfect and does not fully agree with Brandt's figures and descriptions. All the species are new to me, being from further north than any collection I had seen from the west coast. The *Dermaturus* is very interesting, having been described from a single specimen from off Monterey, California, and as far as I know, not since noticed."—Prof. S. J. Smith, 1875.)

Littoral species from near Victoria, V. I., collected by Mr. R. Middleton, in 1875.

Heterograpsus nudus, Stimpson. Five.
" *Oregonensis*, Stimpson. One, very small.
Cancer magister, Dana. Two.
Trichocera Oregonensis, Dana. Four.
Phyllolithodes papillosus, Brandt. One.
Scyra. (Sp. undt.)

("The last species is apparently new; the others are well known and common California and Oregon species, except the *Phyllolithodes*, which is rare in collections at least."—Prof. S. J. Smith, 1875.)

Dredged in the Gulf of Georgia in 15 to 70 fathoms, by Mr. J. Richardson in 1875.
Cancer productus, Randall.
Trichocera Oregonensis? Dana.
Oregonia hirta, Dana.
Eupagurus armatus, (Dana) Stimps.
Clibinarius turgidus, Stimps.

From various localities.

Echidnocerus cibarius, White. The edible crab of Victoria.
Idotea media, Dana. Among seaweed on the beach near Victoria.
Pollicipes polymera, Sowerby. Stones near low water mark at Sooke in the Strait of St. Juan de Fuca.

MISCELLANEOUS.

Supplement to the Second Edition of Acadian Geology, by J. W. Dawson, LL.D., F.R.S. Pp. 102.—This publication contains the new matter added to the 3rd edition of "Acadian Geology" just issued; and which is published separately for the benefit of those who already possess the second edition. It reviews the new facts which have been discovered in the Maritime Provinces of British America since the issue of the second edition in 1868. Beginning with the more recent deposits, the author endeavours to vindicate by new facts his conclusion that the cold of the glacial period in Canada was not connected with a continental glacier, but merely with local glaciers on the mountains and ice-drifted by Arctic currents over the submerged plains. He subdivides the Post-pliocene deposits as follows in ascending order:—

(*a.*) Peaty terrestrial surface anterior to boulder clay.

(*b.*) Lower stratified gravels (Syrtensian deposits of Matthew).

(*c.*) Boulder clay and unstratified sands with boulders. Fauna, when present, extremely Arctic.

(*d.*) Lower Leda clay, with a limited number of highly Arctic shells, such as are now found only in permanently ice-laden seas.

(*e.*) Upper Leda clay and sand, or Uddevalla beds, holding many sub-Arctic or boreal shells similar to those of the Labrador coast at present.

(*f.*) Saxicava sand and gravel, either non-fossiliferous or with a few littoral shells, of boreal or Acadian types.

Passing over the Trias, extensively developed in Prince Edward Island, while it affords the remains of some land-plants and one Dinosaurian reptile, and which in Western Nova Scotia is

remarkable for its great development of trappean rocks, a large space is devoted to the Carboniferous, and more especially to the recognition of a Permo-Carboniferous or perhaps truly Permian development of Red Sandstones in its upper part, containing a peculiar flora in many respects resembling that of the European Lower Permian. Details and figures are also given as to new species of Batrachians, Fishes, Insects and Crustaceans recently discovered, and a detailed analysis of the remarkable development of the Lower Carboniferous or "Sub-Carboniferous" of American Geologists, in comparison with that of other countries.

After a short notice of the Devonian, which in the regions referred to is chiefly remarkable for its rich flora, in the main distinct from that of the Lower Carboniferous, and now numbering 125 described species, the author proceeds to discuss the difficulties attending on the study of the Silurian and Cambrian formations, in a region where they are much disturbed and altered, and associated with igneous beds of very varied character. On this subject he remarks:—

"In the Acadian Provinces, as in some other parts of Eastern America, the great igneous outbursts, evidenced by the masses and dykes of granite which cut the Lower Devonian rocks, make a strong line of distinction between the later and older Palæozoic. While the Carboniferous series is unaltered, except very locally, and comparatively little disturbed, and confined to the lower levels, the Upper Silurian, and all older series, have been folded and disturbed and profoundly altered, and constitute the hilly and broken parts of the country. Further, in the Upper Silurian and the older periods, there seems to have been a constant mixture with the aqueous sediments in process of deposition of both acidic and basic volcanic matter, in the form of ashes and fragments, as well as probably outflows of trachyte and dioritic rock, so that all these older formations are characterized by the presence of felsite and porphyry and petrosiliceous breccia, and of diorite. Further, since these volcanic and tufaceous rocks, owing to their composition, are much more liable to be rendered crystalline by metamorphism than the ordinary aqueous sediments from which the bases have been leached out by water, and since they are usually not fossiliferous, the appearance is presented of crystalline non-fossiliferous rocks alternating with others holding abundant organic remains, and comparatively unaltered.

The volcanic members of these series are also often very irregular in distribution, and there is little to distinguish them from each other, even when their ages may be very different. These circumstances oppose many difficulties to the classification of all the pre-Devonian rocks of Nova Scotia and New Brunswick, difficulties as yet very imperfectly overcome."

In New Brunswick and in Eastern Maine it appears that the Upper Silurian rocks of the "Mascarene" series are capped by felsites, chloritic schists, and agglomerates of great thickness, and having the aspect of Huronian rocks, while in Eastern Nova Scotia similar rocks appear in the lower part of the Upper Silurian. All that part of the Lower Silurian period intervening between the Quebec group and the Utica shale of the interior continental areas seems to have been characterised by the deposition of similar volcanic beds, constituting with a group of overlying metalliferous slates, the "Cobequid series" of the author, and resembling much more the Skiddaw and Borrowdale formations of England than the familiar rocks of the New York system.

Below these however are fossiliferous beds of true Cambrian age. In Cape Breton there have recently been recognised by Mr. Fletcher, fossils indicating an Upper Cambrian group, probably of the horizon of the Lingula flags. Below this is the Acadian series so rich in *Conocoryphe*, *Paradoxides* and other forms characterising the Middle or Lower Cambrian; and the author now regards the auriferous quartzites and slates of the Atlantic coast of Nova Scotia as equivalent to the lowest Cambrian or Longmynd rocks of England. Some portions of this Atlantic coast series, which are associated with intrusive masses and dykes of granite, and which appear as gneisses and mica schists, have been described as Huronian or Laurentian; but the author regards this as an error and considers that they are merely metamorphosed portions of the slates and quartzites.

Distinguishable from all these in New Brunswick, and also in Cape Breton and probably in Western Nova Scotia, are the Huronian and Laurentian systems. In the close of the work an attempt is made to present in a tabular form the equivalency of the older rocks in Acadia and in Great Britain. This is of course somewhat provisional, but may serve to aid comparisons.

England, etc.	Nova Scotia and New Brunswick.
Upper Silurian.	
Ludlow, Wenlock, and Llandovery or Mayhill.	Upper Arisaig Series, Mascarene Series; Lower Arisaig, New Canaan, Wentworth, and Restigouche Series.
Lower Silurian.	
Caradoc and Bala, with Snowdon Felsites and Ash Beds, Coniston and Knock Series.	Upper Cobequid Series, Slates, Felsites, Quartzites and Greenstones.
Great Felsite and Trap Ash Series of Borrowdale (Ward).	Lower Cobequid Series, Felsites, Porphyrites, Agglomerates and Massive Syenite of Cobequids, Pictou, and Cape Breton.
Llandeilo Flags and Shales, Arenig Series, Skiddaw Slates, etc.	Graptolitic or Levis Series of Quebec and North New Brunswick, part of Cape Breton Series.
Cambrian.	
Tremadoc Slates and Lingula Flags.	Miré Series and St. Andrew's Channel Series in Cape Breton,
Menevian.	Acadian Series of St. John.
Longmynd.	Atlantic Coast Series.
Huronian.	
Pebidian and Dimetian Series (Hicks), containing Felsite, Chlorite Schist, and Serpentine.	Huronian Felsites, Chloritic and Epidotic Rocks of St. John, Yarmouth, and of Cape Breton in part.
Laurentian.	
Older Gneisses of Scotland and of Scandinavia.	Gneiss, Quartzite, and Limestone of St. John, Portland Group, Gneiss of St. Anne's Mountain?

It is evident from this table that the Lower Palæozoic and Eozoic formations in the Maritime provinces much more closely resemble those of Great Britain than those of the inland parts of Canada and the United States; though they also resemble the rocks of New England and the Eastern Appalachian region generally, as well as those of some parts of Eastern Quebec. The succession deduced from the study of the inland continental plateau is thus incapable of being applied successfully to that in the sea-coast where great igneous actions were going on upon the Atlantic margin of both continents, contemporaneously with tranquil deposition of ordinary aqueous beds on the interior submerged plateau.

Description of a New Species of Paragorgia from Jervis Inlet, B.C. By Prof. A. E. Verrill.

Paragorgia Pacifica Verrill. Corallum large, very much branched, irregularly dichotomous, the branches trending somewhat in a plane. In the single specimen obtained, several large branches arise from close to the base and diverge at wide angles, so that the coral is broader than high; these subdivide very soon into numerous branches, which, like their branchlets, start out nearly at right angles and then bend upward, thus producing broad rounded axils. The branchlets are nearly round, slender for this genus, slightly irregular, variable in length, and mostly swollen at the tip. The polyp-cells are irregularly scattered, moderately large, eight-rayed and mostly sunken in contraction. Between the polyp cells there are numerous openings, like pin-punctuers, apparently corresponding to rudimentary zoöids, analogous to those found in *Sarcophyton* and the Pennatulaceæ. Similar small openings exist in *Paragorgia arborea*. Cœnenchyma moderately thick, axis porous, brittle, composed mostly of elongated, rough spicula. Color bright red-lead or orange-red, axis pale yellow. Diameter of the branchlets .25 to .35 of an inch; distance between their divisions 1 to 2.5 inches. Total height of the specimen about 16 inches. The spicula composing the outer layer of the cœnenchyma are very small, short and rough, varying from forms that are but little longer than broad to those that are nearly twice as long as broad, mostly with a whorl of about four rudely subdivided warts close to each end, the end itself consisting of a small, rough rounded tubercle; between the whorls of warts there is a narrow naked middle space. Beneath the outer layer the cœnenchyma is filled with many much larger stout fusiform light red spicula, varying in size and form, which bear rudely conical, divergent spicules, arranged irregularly in two to four or more remote whorls, one of which is often central; the ends of these spicula are prominent and more or less spinulous; they are often three times as long as broad, but smaller and shorter ones are mingled with them. The axis contains much larger and longer whitish fusiform spicula, often six to eight or more times longer than thick, with a wide median naked space, and with about three distant irregular whorls of rough, conical, spinulose prominences, those next the ends often much the largest and subdivided or rudely branched. The specimen was obtained at Jervis Inlet by Mr. Richardson. This form is closely allied to *Paragorgia arborea*, found on both sides of the North Atlantic, and abundant in deep water off Nova Scotia, in 200 to 300 fathoms, hard bottom. The latter, although very variable as to the size and style of its branches, is a much coarser and stouter form, with thicker and more irregular branchlets.

(This is the coral referred to on page 466 of Mr. Whiteave's paper in the in the present number.)

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